Brown and Caldwell

Historic Drainage Analysis
LCP Chemicals Inc. Superfund Site
Linden, New Jersey

Revised October 2006
July 2004

HISTORIC DRAINAGE ANALYSIS
LCP CHEMICALS INC. SUPERFUND SITE
LINDEN, NEW JERSEY

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1.0 INTRODUCTION

This report presents the results of an analysis of patterns of groundwater flow and historic surface drainage between the LCP Chemicals, Inc., Superfund Site (hereinafter referred as the LCP site) and the adjacent ISP-ESI site, located in Linden, New Jersey. This analysis has been conducted to evaluate whether or not the LCP site was historically connected to Piles Creek.

This document was originally submitted for agency review in July 2004. The October 2006 revision of the Historic Drainage Analysis report, contained herein, was modified in response to comments from Ms. Carole Petersen of USEPA dated February 6, 2006 as described in a letter to USEPA dated March 10, 2006. These modifications primarily include technical clarifications to the original document.

Piles Creek is a tidal creek located approximately 2,200 feet north of the LCP site. The area between the LCP site and Piles Creek is occupied by the ISP-ESI site. Piles Creek originates in the tidal marshlands located northwest of the LCP site, west of the New Jersey Turnpike and flows easterly into the Arthur Kill. In their letter dated March 12, 2003, USEPA, Region II, suggested that constituents from the LCP site might be present in surface waters and sediment on the ISP-ESI site property and from there have migrated to Piles Creek due to the possibility of a historical connection from LCP across the adjacent ISP-ESI site to Piles Creek.

The ISP-ESI property was developed for industrial production on filled tidal marshland starting in about 1919. The site was operated for chemical production under a variety of ownerships and names, the most recent being the former GAF Chemicals Corp (GAF) plant, which ceased operation in 1991. Industrial production at the former LCP facility, located immediately south of the ISP-ESI site, began much later in 1955 and continued until 1982.

Subsurface groundwater investigations at the LCP and ISP-ESI sites have revealed that groundwater flow patterns are substantially controlled by the surface water features in and

around the site including the Arthur Kill, Piles Creek, and the on-site ditch system. As the dominant regional groundwater discharge feature, the Arthur Kill influences groundwater on the LCP site and the eastern portions of the ISP-ESI site to flow toward the Arthur Kill and away from Piles Creek, as shown on Figures 1-1 and 1-2.

A system of surface drainage channels historically existed on the ISP-ESI site that was used to convey cooling water, wastewater, and stormwater runoff to be treated prior to discharging into the Arthur Kill. From 1955 until about 1977, the drainage systems of the ISP-ESI site flowed through the LCP site to the Arthur Kill; during this time, the drainage from each site was interconnected.

The historic development of the surface drainage channels is shown on a series of maps, (Figures 1-5 through 1-9). These figures depict the historic locations of the drainage channels at the ISP-ESI and LCP sites within the context of the former industrial development at the sites. Figures 1-5 and 1-6 also depict the locations of the natural tidal channels that bordered Arthur Kill and Piles Creek prior to the filling of portions of the area for industrial development. Finally, the Arthur Kill and the various existing tidal creeks, including South Branch Creek and Piles Creek (located approximately 2,200 feet northwest of the LCP site on the far [north] side of the adjacent ISP-ESI site), are shown on Figure 1-6.

The physical character and location of surface water channels on the ISP-ESI and LCP sites, as well as the location of South Branch Creek, have been altered during the period of operation of industrial activities at the LCP site. The aerial photograph review, contained within, follows these alterations step by step and illustrates that, due to surface structures and dams, water flowing from the LCP site would have been confined to the southeast portion of the ISP-ESI Site and would not have traveled entirely across the ISP-ESI site to have made contact with Piles Creek.

The evaluation presented herein presents a discussion of groundwater flow and surface water flow patterns on the LCP and ISP-ESI sites. The surface water evaluation includes a study of 14 aerial photographs between April 20, 1951, and Spring 2002, as well as evidence

from recent survey data on the construction of the culvert connecting the eastern and western portions of the ISP-ESI site. The selection of dates for the aerial photographs was chosen to overlap with the time period that gaseous chlorine was manufactured on the LCP site, between 1955 and 1982 in addition to photographic dates prior and subsequent to the operation of the plant.

1.1 GROUNDWATER FLOW

The geologic and hydrogeologic conditions beneath the LCP and ISP-ESI sites have been investigated in significant detail in subsurface investigations performed at each site. Data from these investigations are presented, respectively, in the documents titled "Site Characterization Summary Report, LCP Chemicals Superfund Site, Linden, New Jersey", (Brown and Caldwell, 2002) and "Remedial Investigation Report, ISP Environmental Services Inc. (ISP-ESI), GAF Chemicals Corporation Site, Linden, Jersey", (Eckenfelder Inc., 1991). In addition, a numerical groundwater flow model was developed using these data for the purpose of developing and evaluating the groundwater remediation system at the ISP-ESI Linden facility as presented in "Final Groundwater Flow Model Report for the ISP Linden Site", (Brown and Caldwell, 2002). The groundwater flow conditions beneath the LCP and ISP-ESI sites are described briefly below.

1.1.1 Geologic Conditions

The geology of the LCP and ISP-ESI sites consists of four principal units, as follows:

- An upper layer of man-made Fill,
- Marine Tidal-Marsh Deposits,
- Glacial Till, and
- Passaic formation bedrock.

Each of these units is described below:

Fill

A manmade layer of heterogeneous fill, placed in the tidal marshland to allow industrial development of the area, covers the vast majority of the site. Historically, most of the filling occurred during industrial expansion of the Site prior to 1960. The fill stratum extends laterally throughout most of the Site, ranging in thickness, where present, up to 16 feet, with an average thickness of approximately 9 feet. This unit primarily consists of an irregular mixture of soil, construction debris, and process wastes.

Marine Tidal Marsh Deposits

The fill is underlain throughout the plant site by marine tidal marsh deposits of Recent age. In general, these deposits consist of an upper layer of meadow mat and peat, gradationally underlain by an organic clay and silt. The marine tidal marsh deposits appear to be continuous across the site. Nevertheless, the Marine Tidal Marsh Deposits are likely locally penetrated by the construction of manmade drainage or "mosquito" ditches and the installation of piles and other manmade penetrations associated with the construction of former and existing facilities at the site. The organic clay and silt generally varies in thickness from 1.5 to 6 feet across the site, generally thickening toward the east.

Glacial Till

Underlying the marine tidal marsh deposits is a continuous layer of glacial till of Pleistocene age. Glacial till represents ground moraine deposits formed from the scouring and subsequent redeposition of the underlying Passaic formation by the glacial ice. This is evidenced by the similar red-brown color. The glacial till consists of a clayey and silty sand with minor amounts of gravel and cobbles.

Passaic Formation

The ISP-ESI site, and the region as a whole, is underlain by the Passaic formation of Jurassic age. The Passaic formation consists of moderately dipping beds of sandstone and shale. A

thin layer of weathered rock, or saprolite, has been observed on the site. The top of competent rock ranges from 14 feet below mean level in the western portion of the site to 44 feet below mean sea level near the Arthur Kill. The Passaic formation is not a significant water supply aquifer in the immediate vicinity of the site due to brackish water conditions (there are no water supply, production or irrigation wells within a two mile radius of the site). Groundwater flow occurs primarily along fractures and, to a lesser extent, faults within the formation.

1.1.2 Groundwater Occurrence and Flow

Within the framework of the aforementioned geologic materials, three distinct hydrogeologic zones exist at the site, including:

- The uppermost water-bearing zone contained within the Fill and the peat subunit of the Tidal Marsh deposits, termed the "overburden water-bearing zone".

- An aquitard consisting of the organic silt & clay subunit of the Tidal Marsh Deposits (where present) and the Glacial Till.

- An aquifer contained within the upper portion of the Passaic Formation bedrock, termed the "bedrock water-bearing zone".

Overburden Water-Bearing Zone

The overburden water-bearing zone occurs predominantly within the fill material. The potentiometric surface of the overburden water-bearing zone (the water-table surface), is complex, being controlled largely by the ditches and other surface water bodies that exist throughout and around the sites. While the locations of the ditches have been changed over the years (Sections 1.2 and 2), the overall effect of these ditches on the pattern of

groundwater flow is basically the same. That is, groundwater mounding occurs between the ditches as a result of infiltration of precipitation. Groundwater then flows laterally from the mounded areas to discharge to the ditches and other surface water bodies around the site.

The pattern of groundwater flow within the overburden water-bearing zone has been characterized by water table mapping performed for each in the aforementioned site investigation reports. Various water table contour maps and groundwater model simulations that define the water table configurations are presented in Figures 1-1, 1-2, and 1-3. These maps characterize groundwater and surface water flow patterns that were representative of the GAF site from 1966 until 2003. While groundwater elevation data are not available for the site prior to about 1987, characterization of groundwater flow conditions prior to this time has been made as follows:

- 1977 through 2003 - The flow directions upgradient of the LCP site were determined based on the GAF RI data surface water and groundwater flow data collected in 1990 and 2002, as above. These data are considered to be representative of the period from 1977 through 2003 given the fact that site drainage conditions were relatively unchanged during this period.

- 1966 through 1977 - The flow conditions in the western portion of the site were substantially unchanged from the conditions observed in 1990. Accordingly, the flow conditions during this period were based on a qualitative extrapolation of the 1990 data to the 1966 through 1977 period.

- 1955 through 1966 - The groundwater flow conditions in the western portion of the site are anticipated to be somewhat different than the period after 1966 given the changes in the surface drainage system, including the wastewater conveyance system, that occurred prior to 1966 (Section 2) and based on the demonstration that shallow groundwater is controlled at this site by the pattern of surface water flow.

Data obtained as part of the Phase I LCP RI (Figure 1-1) conclusively support the finding that shallow groundwater beneath the LCP Site flows easterly to the Arthur Kill. Specifically, shallow groundwater flow at the LCP site is controlled by the interaction of the shallow groundwater with the various drainage ditches, including South Branch Creek. Accordingly, groundwater from the southwestern portion of the LCP site flows toward and discharges to the ditch located south of the railroad tracks. In the northeastern portion of the LCP site the groundwater flows toward and discharges into the South Branch Creek. Each of these ditches flows to the Arthur Kill.

In summary, overburden groundwater beneath the LCP site does not flow toward Piles Creek. Furthermore, past groundwater flow patterns from the LCP site would also not have flowed toward Piles Creek given the historical patterns of surface water flow.

Bedrock Water-Bearing Zone

An aquifer exists within the competent bedrock of the Passaic formation. The Arthur Kill represents the dominant, regional discharge area for groundwater flow within the bedrock. Site-specific mapping of the bedrock piezometric surface (Figure 1-4) confirms the regional mapping (Anderson, 1968) in which bedrock groundwater flows to the east towards the Arthur Kill. This observed pattern of bedrock groundwater flow has been shown to be relatively unaffected by the shallow ditch systems at the site and is also confirmed by groundwater flow simulations using the numerical groundwater flow model. Furthermore, the LCP site is located immediately adjacent to the Arthur Kill while Piles Creek is nearly ½ mile distant in an upgradient direction from LCP. Accordingly, bedrock groundwater flow from the LCP site does not and would not historically have flowed toward Piles Creek.

1.2 SURFACE DRAINAGE SYSTEM

1.2.1 ISP-ESI Site Surface Drainage

As mentioned above, surface drainage channels that long predated LCP operations were constructed over much of the ISP-ESI site (Figures 1-5 and 1-6). The channel system was

utilized by the former ISP-ESI manufacturing facility and its predecessors for the conveyance of stormwater runoff from the majority of the ISP-ESI site, cooling water and other wastewaters to the Arthur Kill and later to ISP-ESI's wastewater treatment plant (WWTP). The character of the channels was different in various areas of the ISP-ESI site.

The channels in the western half of the site were relatively wide and in some areas resembled ponds. The channels within the former manufacturing areas, in the eastern half of the ISP-ESI site, were narrower, and many were constructed with vertical, wooden sides. The discharges from the eastern channels were treated for several decades prior to the construction of the current WWTP, employing equalization, skimming, and lime neutralization prior to discharge to the Arthur Kill by way of South Branch Creek. This early treatment was performed in several different locations on the LCP and ISP-ESI sites. The channels continued to be used to convey the process water and stormwater flow to the current WWTP, constructed in 1977, which discharges directly to the Arthur Kill.

Prior to the start up of the current ISP-ESI WWTP, the channel system discharged to the Arthur Kill through either of two channels. Some portions of the margins ISP-ESI site continued to drain to small ditches not connected to the channel system. The northern of the two South Branch Creek channels, which corresponds to the original location of South Branch Creek (Figures 1-5, 1-6, and 1-7), was used for the longest period of time, up to approximately 1971. The southern channel, which is the current location of what is referred to as South Branch Creek (Figure 1-8), was used for a shorter time, from 1971 to 1977, when the current ISP-ESI WWTP was placed into operation. After 1977, the channel system continued to discharge to the currently existing WWTP on the ISP-ESI site (Figure 1-9).

1.2.2 LCP Site Drainage

Industrial process water and stormwater flow from the LCP site was historically connected to South Branch Creek via the ISP-ESI drainage channel system prior to its ultimate discharge to the Arthur Kill. This connection with the ISP-ESI drainage system was on the eastern side of the ISP-ESI site, just upstream of the discharge to the Arthur Kill. The drainage in and around the LCP site was modified several times, and is described as follows:

Prior to 1947

Prior to 1947, South Branch Creek flowed from the area located south of the ISP-ESI production area and flowed eastward across the center of what would later become the LCP site to discharge to the Arthur Kill (Figure 1-5). It should be noted that the tidal marshland drainage to South Branch Creek, which discharged to the Arthur Kill, was discrete and separate from the Piles Creek drainage.

1947 to 1951

Starting in 1947, South Branch Creek was diverted to an alignment that looped around the southern area of the future LCP production area prior to discharging to the Arthur Kill. Starting in the same year, filling of the portion of the creek in what would become the production area of the LCP site started to occur in preparation for industrial development of the site.

1951 to 1966

Construction of the southern loop realignment of South Branch Creek was completed by 1951, after which the LCP plant site was built (Figure 1-6). The LCP site started operations in 1955. The South Branch Creek channel continued to flow to the Arthur Kill from the southeastern portion of the ISP-ESI site, as described above, around the southern end of the LCP site, until 1966. During this time, water in South Branch Creek was treated in an area located immediately east of the electrical switchyard on the LCP site.

1966 to 1971

South Branch Creek was relocated by 1966 into a covered channel (or "flume") located along the northern border of the LCP site (Figure 1-7). The WWTP was apparently moved at this time to be located several hundred feet upstream of the covered channel to the ISP-ESI property.

The portion of South Branch Creek that previously looped around the southern side of the site was replaced by a continuous concrete drainage trench. This trench surrounding the process area was utilized after 1966 to collect storm water runoff and excess runoff from LCP Buildings 230 and 240. The flows in the trench were routed to a concrete sump south of Building 231 before being pumped to holding tanks outside Building 233. The water was pH adjusted, filtered, polished with carbon, and stored pending annual or semi-annual discharge to South Branch Creek.

After 1971

Around 1971, the South Branch Creek channel located east of the railroad tracks was relocated into a newly created, narrow man-made channel that discharged to the Arthur Kill approximately 950 feet south of the former South Branch Creek channel (Figures 1-8 and 1-9).

The process wastewater from the mercury cell buildings drained to concrete floor trenches where it was collected in the northwest corner of each building. The process wastewater was pumped to holding tanks and eventually pumped to the wastewater treatment plant on the ISP-ESI site. This wastewater treatment arrangement was used by LCP until the plant ceased operation in 1982.

The aforementioned arrangement of the LCP drainage system with regard to the ISP-ESI site supports the fact that Piles Creek should not have received runoff from the LCP site. This is demonstrated by the fact that, for the time period in question, the entire eastern portion of the ISP-ESI drained to the east by way of the LCP site. The LCP site drainage connected to this system just before the point where it discharged to the Arthur Kill. Therefore, for LCP drainage to flow to Piles Creek, it would have had to flow upstream a distance of nearly ½ mile across the ISP-ESI site.

Evidence is presented in Section 2.0 that reveals the lack of a physical connection from the drainage system in the eastern portion of the ISP-ESI site (to which LCP connected) over

most, if not all, of the period that the LCP site was in operation. Therefore, even in the unlikely event that the ISP-ESI drainage system were to have temporarily reversed itself and flowed back across the site, it is extremely unlikely that LCP drainage could have flowed all the way to Piles Creek. This is due to the fact that LCP is located at the foot of the surface drainage system on the edge of the Arthur Kill while Piles Creek is located nearly ½ mile distant in an upstream direction of LCP.

2.0 AERIAL PHOTOGRAPHIC ANAYSIS

In this section, an analysis of a selection of many high-resolution photographs is presented. These include both high-altitude and low-altitude photographs that are available for the LCP and ISP-ESI Linden sites, located within the Grasselli Point area of Linden, New Jersey. These aerial photographs were purchased from a number of commercial aerial photography sources.

The methodology utilized to prepare this aerial photogrammetric interpretation included the following steps:

- Obtained and digitized aerial photographs at high resolution.
- Imported the scanned images into the Geographic Information System (GIS) for the site by georeferencing the photos to the New Jersey State Plane coordinate system.
- Overlaid geographic data (e.g., property lines) over the photographs.
- Displayed the photographs at two different map scales for subsequent analysis.
- Analyzed aerial photographs.
- Annotated digitized aerial photographs.

The analysis methods and annotation format presented is similar to those presented in the aerial photographic analysis prepared by EPA for the LCP site (USEPA, March 1999). The narrative provided below describes the results of the aerial photographic interpretation, including annotations to identify objects and features observed on the aerial photographs.

Each of the photographs is shown in two views. The first is a close-up view of the northwestern section of the ISP-ESI site at a scale of 1" = 200 ft. The second is a larger view (1" = 400 ft) that also shows the area from the LCP site northward to Piles Creek. Each of the key features that are annotated on the close-up view is also annotated on the corresponding large view.

APRIL 20, 1951, PHOTOGRAPH

Close-up View (Figure 2-1)

Prior to the development of the LCP site, the western marsh area of the ISP-ESI Linden facility is undeveloped, as of 1951. The area consists largely of unfilled tidal marshlands into which "mosquito" (drainage) ditches have been excavated. The tidal marshland is connected to Piles Creek through a channel that extends beneath a bridge along Grasselli Road. Hydraulic separation between channel C1 and tidal creek channel TC1 is inconclusive due to the presence of an unknown structure separating the two water bodies as of this date. Channel C1 is separated into northern and southern portions by a culvert.

Large View (Figure 2-2)

Each of the features, described above, on the close-up view is depicted on the large view map on Figure 2-2.

As shown in the large-view photograph, the location of South Branch Creek is observed in the southeast corner of the ISP-ESI site where it flows across the center of the future LCP site. South Branch Creek connects and discharges to the Arthur Kill at a point on the ISP-ESI site, located approximately 750 feet north of the current discharge point. A box culvert (CT) is under construction along the southern loop of South Branch Creek.

Construction of the LCP facility has not started. However, the loop of South Branch Creek around the southern side of what would become the LCP facility is evident.

APRIL 20, 1954, PHOTOGRAPH

Close-up View (Figure 2-3)

In 1954, the western marsh area of the ISP-ESI Linden facility remains undeveloped. After April 20, 1951 (refer to Figures 1-5, 1-6, and 1-7), the fill area (FL) located between channel C1 and tidal creek channel TC1 has expanded to completely separate channel C1 and tidal creek channel TC1. Therefore, channel C1 was hydraulically separated from tidal creek channel TC1 and Piles Creek and the unknown structure is unquestionably gone. This hydraulic separation is significant, as this eliminates a potential hydraulic connection between the LCP site and Piles Creek prior to the construction and operation of the LCP site.

Large View (Figure 2-4)

Each of the features described above on the close-up view is depicted on the large-view map on Figure 2-4.

At the southern-most point of channel C1, the channel meanders southeast across the southeast portion of the ISP-ESI site, connecting channel C1 on the ISP-ESI site to South Branch Creek at its original location. Channel C1 flows across the ISP-ESI site to South Branch Creek on the ISP-ESI site, located approximately 750 feet north of the current discharge point. The box culvert (CT) along the southern loop of South Branch Creek is still visible.

Construction of the LCP facility has commenced.

MAY 16, 1954, PHOTOGRAPH

Close-up View (Figure 2-5)

There are no noticeable differences since April 20, 1954 (Figure 2-3).

Large View (Figure 2-6)

Each of the features described above on the close-up view is depicted on the large-view map on Figure 2-6.

NOTE: Two dark straight lines that intersect on the eastern portion of the site are not believed to be related to site features (i.e., an artefact on the photograph).

NOVEMBER 20, 1958, PHOTOGRAPH

Close-up View (Figure 2-7)

After May 16, 1954 (refer to Figure 2-5), the Ethylene Oxide Plant (EOP) and Building 120 (B120) have been constructed in the western marsh area of the ISP-ESI Linden facility. Additionally, an east-west road (R1) has been constructed connecting the EOP to the manufacturing area located in the eastern portion of the facility. Road R1 intersects a newly constructed road (R2) running in a north-south direction, west of channel C1. The western marsh has been divided into northern and southern cells by road R1 (4th Street), R1 effectively provides hydraulic separation between the northern and southern cells, preventing the flow of water from the southern cell to Piles Creek.

Channel C1 contains a fill area (FL) that has even more completely separated the north and south sections of channel C1 and partially fills in the north portion of channel C1.

The fill area (FL) located between channel C1 and tidal creek channel TC1 has expanded during the time interval following May 16, 1954 (Figure 2-5), to partially fill tidal creek channel TC1. The previously observed (April 20, 1951 and May 16, 1954) eastern portion of tidal creek channel TC1 has been filled and Building 120 (B120) has been constructed in this area (refer to Figures 1-5 to 1-9). There continues to be no connection between channel C1 and tidal creek channel TC1 and hence Piles Creek.

The previously observed (April 20, 1951 and May 16, 1954) tidal creek channels TC2, TC3, and TC4 were filled either partially or completely to enable construction of the EOP at this location.

Mosquito ditch (MD1) has been split into north and south sections as a result of the construction of road R1. Additionally, the northern portion of mosquito ditch MD1 has been filled to enable construction of Building 120 (B120).

It is possible that after the road to the ethylene oxide plant (R1) was built, the presence of ponding south of R1 led to the construction of culvert CT3 (Figure 2-7) west of the southern portion of channel C1 to connect the western marsh area to the eastern manufacturing facility in an attempt to allow the standing water to drain to channel C1. This culvert is evidenced by the apparent presence of inlet/outlet channels on each end of the culvert. According to an available survey drawing, the invert elevations for culvert CT3 under the access road were +2.74 ft. at the west end and +2.63 ft. at the east end, indicating that by design and installation, the intended flow direction at the time this pipe was installed was from west to east. The presence of culvert CT3 has no bearing during this period regarding a hydraulic connection from channel C1 to Piles creek as the elevated road (R1) acts as a berm to prevent the flow of water northward to Piles Creek.

Standing water (SW) is visible in the southern cell of the western marsh, indicating that water is being impounded and does not flow through culvert CT3. This could be because culvert CT3 does not in fact exist as of this date. Alternatively, the water level in the southern cell of the marsh may be maintained by relatively high heads in channel C1. Two fill areas (FL) are located near the standing water (SW) within the southern cell.

While the LCP site is likely to be hydraulically connected to channel C1, channel C1 is clearly located hydraulically upgradient of the LCP site in the center of the ISP-ESI site. This conclusion is established on the basis of the configuration of the drainage channel that carries process water and stormwater from the former production area on the ISP-ESI site to the east to Arthur Kill, as shown on Figure 2-8. Additionally, these findings are consistent with the topographic data that were obtained later as part of the RI in 1990.

Large View (Figure 2-8)

Each of the features described above on the close-up view is depicted on the large view map on Figure 2-8.

The southern portion of channel C1 that meanders southeast has been separated into two sections by a fill area (FL), although the two sections have been connected with a culvert (CT4). A fill area (FL) has been added along South Branch Creek on the LCP site where a portion of South Branch Creek has been rerouted below ground. The box culvert (CT) along the southern loop of South Branch Creek is still visible.

Construction activities have continued on the LCP facility with the addition of other buildings, storage tanks, and the electrical switchyard.

APRIL 3, 1959, PHOTOGRAPH

Close-up View (Figure 2-9)

The standing water (SW) visible on November 20, 1958 (refer to Figure 2-7), in the southern cell of the western marsh has expanded, thereby indicating water cannot drain from the southern cell. This flow blockage is likely due to the non-existence of the culvert (CT3) connecting the western marsh area to the eastern manufacturing facility and/or the elevated head in channel C1.

The standing water (SW) observed on November 20, 1958, in the northern portion of channel C1 is absent.

Large View (Figure 2-10)

Each of the features described above on the close-up view is depicted on the large view map on Figure 2-10.

There are no noticeable differences in the LCP facility, channel C1, and South Branch Creek on the LCP site since November 20, 1958 (Figure 2-8).

APRIL 23, 1961, PHOTOGRAPH

Close-up View (Figure 2-11)

The standing water (SW) visible in the south-western portion of the site has expanded subsequent to April 3, 1959, indicating that water still cannot drain from the southern cell. There continues to be no connection between the northern and southern cells of the western marsh area due to road R1, indicating that there is no flow of water between the southern cell and Piles Creek. The two fill areas (FL) located near the standing water have expanded following April 3, 1959.

The standing water (SW) that was absent from the northern portion of channel C1 in April 3, 1959 (Figure 2-9), is again visible.

Large View (Figure 2-12)

Each of the features, described above on the close-up view is depicted on the large view map on Figure 2-12.

There are no noticeable differences in the LCP facility, channel C1, and South Branch Creek on the LCP site since April 3, 1959 (Figure 2-10).

DECEMBER 4, 1966, PHOTOGRAPH

Close-up View (Figure 2-13)

After April 23, 1961, a fill area (FL) located near Piles Creek was added in an east-west direction across the northern portion of the tidal creek channels in preparation for

construction of a dam separating tidal creek channels from Piles Creek. Tidal creek channels TC1, TC2, and TC3 are observed to contain more water than was previously observed which may be caused by a constriction of tidal flows from Piles Creek resulting from the addition of the fill.

The marsh area south of road R1 has been nearly completely filled in (FL). A bridge (BR) has been constructed beneath road R1, connecting the northern and southern cells of the western marsh. The bridge (BR) provides hydraulic communication between the southern and northern cells of the western marsh which may have been required to accommodate the water that has apparently backed up from the placement of fill (FL) in preparation for the construction of a dam.

The fill area (FL) located near the standing water observed on April 23, 1961, has expanded to almost completely fill this area. The standing water (SW) observed in the southern cell of the western marsh on April 23, 1961 (refer to Figure 2-10) is largely absent.

Overhead power lines (OPL) were constructed in this fill area (FL).

After April 23, 1961, the northern portion of channel C1 received fill (FL) to partially backfill the channel.

Large View (Figure 2-14)

Each of the features described above on the close-up view is depicted on the large view map on Figure 2-14.

A fill area (FL) has been added to the portion of the South Branch Creek located on the LCP manufacturing portion of the property. Additional fill has been added along the South Branch Creek on the LCP site where more of South Branch Creek has been rerouted into a covered channel. The box culvert (CT) visible along the southern loop of South Branch Creek in 1961 has been completed and covered. A system of wooden flumes and concrete trenches have been added to connect South Branch Creek between Avenue B and

Avenue C, which extend northward along Avenue C, then extend westward along the northern boundary of the site across Avenue D and connect into the ditch system of the ISP-ESI site. The portion of the South Branch Creek remaining above ground is located east of the manufacturing area of LCP. Some of the standing water (SW) observed on April 23, 1961, in the southern section of channel C1 that meanders southeast is absent. A fill area (FL) has been added to the eastern-most portion of the southern section of channel C1.

Additional construction activities have occurred on the LCP facility since April 23, 1961.

APRIL 11, 1967, PHOTOGRAPH

Close-up View (Figure 2-15)

The high water levels in tidal creek channels TC1, TC2, and TC3 continue to be visible which are likely caused by a constriction of tidal flows from Piles Creek caused by the addition of fill (FL) in preparation for the construction of a dam separating the tidal channels from Piles Creek.

The standing water (SW) observed on December 4, 1966 (refer to Figure 2-13), in the southern portion of channel C1 is absent in some areas of the channel.

Large View (Figure 2-16)

Each of the features described above on the close-up view is depicted on the large view map on Figure 2-16.

There are no noticeable differences in the LCP facility, channel C1, and South Branch Creek on the LCP site since December 4, 1966 (Figure 2-14).

APRIL 16, 1968, PHOTOGRAPH

Close-up View (Figure 2-17)

After April 11, 1967 (refer to Figure 2-14), the construction of a dam has been completed between the tidal creek channels and Piles Creek. As a result of the dam, standing water (SW) is visible in the northern area of the marsh, indicating that this area no longer drains to the north to Piles Creek. In fact, the northern cell of the marsh has been completely flooded, eliminating the tidal creek channels previously visible. Water from these areas likely flows through culvert CT3 into channel C1.

A fill area (FL) is located in the northern cell north of road R1.

Standing water (SW) is visible in the southern cell of the marsh along a channel.

The standing water (SW) that was absent from the southern portion of channel C1 on April 11, 1967, is again visible.

Large View (Figure 2-18)

Each of the features described above on the close-up view is depicted on the large view map on Figure 2-18.

The standing water (SW) that was absent from the southern portion of channel C1 on April 11, 1967, is again visible.

There are no noticeable differences in the LCP facility and South Branch Creek on the LCP site since April 11, 1967 (Figure 2-16).

APRIL 9, 1977, PHOTOGRAPH

Close-up View (Figure 2-19)

The presence of the dam continues to provide hydraulic separation between the ISP-ESI site and Piles Creek. After April 16, 1968 (refer to Figure 2-17), the fill area (FL) in the northern marsh has expanded. Evidence of impounded water in the western marsh indicates that water does not flow from the southern and northern cells of the western marsh to Piles Creek due to the presence of the dam. Water apparently flows from the western marsh area east through culvert CT3 to channel C1.

Standing water (SW) is visible east of channel C1.

Large View (Figure 2-20)

Each of the features described above on the close-up view is depicted on the large view map on Figure 2-20.

The previous course of South Branch Creek from Avenue B to the Arthur Kill was altered between April 16, 1968, and 1972 to allow the construction of the ISP-ESI WWTP at its present location. Accordingly, the portion of South Branch Creek east of the railroad tracks is now a narrow channel that discharged to the Arthur Kill on the LCP site, located approximately 950 feet south of the former South Branch Creek channel.

There are no noticeable differences in the LCP facility since April 16, 1968 (Figure 2-18).

DECEMBER 22, 1978, PHOTOGRAPH

Close-up View (Figure 2-21)

There are no noticeable differences since April 9, 1977 (refer to Figure 2-19). Impounded water in the western marsh indicates that there is no flow from the southern and northern

cells of the western marsh to Piles Creek due to the presence of the dam. Water from the western marsh area flows east through culvert CT3 to channel C1.

Large View (Figure 2-22)

Each of the features described above on the close-up view is depicted on the large view map on Figure 2-22.

There are no noticeable differences in the LCP facility, channel C1, and South Branch Creek on the LCP site since April 9, 1977 (Figure 2-20). However, the present WWTP plant consisting of the three large lagoons is now operational which means that South Branch Creek is no longer used as a waste water discharge.

NOVEMBER 15, 1988, 1995, AND SPRING 2002 PHOTOGRAPHS

Close-up View (Figures 2-23, 2-25, 2-27)

There are no noticeable differences since December 22, 1978 (refer to Figure 2-21). Impounded water in the western marsh indicates that there is no flow from the southern and northern cells of the western marsh to Piles Creek due to the presence of the dam. Water from the western marsh area flows east through culvert CT3 to channel C1.

Large View (Figures 2-24, 2-26, 2-28)

Each of the features described above on the close-up view is depicted on the large view map on Figures 2-24, 2-26, and 2-28.

There are no noticeable differences in the LCP facility, channel C1, and South Branch Creek on the LCP site since December 22, April 9, 1977 (Figure 2-22).

3.0 SUMMARY

An evaluation of available data reveals that groundwater and surface water from the LCP site would not have flowed historically from the LCP site to Piles Creek. The conclusions regarding the patterns of groundwater flow are based on site-specific groundwater investigations and associated numeric groundwater flow modeling in which groundwater in the area of the LCP site is shown to flow eastward toward the Arthur Kill. Notwithstanding the fact that surface drainage from the LCP site was connected to the ISP-ESI ditch system, the data show that it was for the function of letting the ISP-ESI ditch system flow through the LCP site (and not vise versa) that surface drainage from the LCP site would not have flowed across the ISP-ESI site to Piles Creek. Both groundwater and surface water from the LCP site would have followed current flow patterns and would have flowed historically to the Arthur Kill.

The site surface drainage history was performed using available aerial photographs and other site data. The data reveal that drainage would not have flowed from the LCP site to Piles Creek. While the LCP drainage system was physically connected to the ISP-ESI drainage channel system, the LCP site was on the downstream end of the system. Therefore, water from the ISP-ESI site flowed through the LCP site to discharge to the Arthur Kill. Furthermore, the portion of the ISP-ESI drainage channel system to which LCP was connected was hydraulically separated from Piles Creek for most, if not all, of the period that the LCP site was in operation. Therefore, waste materials from LCP site would not have flowed to or discharged to Piles Creek.

The ISP-ESI and LCP sites utilized an interconnected system of surface channels to convey cooling water, wastewater, and stormwater runoff. This water was treated and then discharged to the Arthur Kill, via South Branch Creek, from 1955 until 1977, when the new ISP-ESI WWTP started operation. Four (4) different alignments of South Branch Creek have flowed from the ISP-ESI site and through the LCP site to discharge to the Arthur Kill:

- Natural tidal channel prior to filling and development of the site (Figure 1-5).

- Man-made alignment looping to the south around the future LCP site from 1951 to 1966 (Figure 1-6).

- Man-made alignment, after 1966, into a covered channel (flume) replacing the southern loop around the LCP site (Figure 1-7).

- Creation of a new, man-made channel discharge to Arthur Kill 950 feet south of the former South Branch Creek channel (1966 to present).

Due to its proximity with the Arthur Kill, the LCP connection to the ISP-ESI channel system (South Branch Creek) was located a relatively short distance upstream of the discharge to the Arthur Kill. Therefore, while the systems were interconnected, flow from the LCP site would not have flowed upstream and backwards through the WWTPs over the ISP-ESI site to Piles Creek.

In addition to the flow patterns described above, the drainage channel system in the eastern half of the ISP-ESI site, which was the portion connected to the LCP site, was hydraulically separated from Piles Creek for the entire period that the LCP site was in operation. A possible exception to this statement is a brief period from about 1966 to 1968, after construction and filling activities began to eliminate hydraulic connection to Piles Creek prior to final completion of the dam. Even so, the surface water drainage patterns indicate that surface water originating from LCP would not have flowed upstream across the ISP-ESI site. At other times between 1955 and the present, separation was afforded by the lack of a hydraulic connection between the various site drainage channels. (Figures 1-5 through 1-9) The hydraulic separation between the eastern and western portions of the site was progressively eliminated by the construction of a bridge and culvert in around 1961 and 1966 or 1968, respectively. However, a dam was constructed in 1968 that provided a positive separation between the ISP-ESI drainage channel system and Piles Creek.

It should be noted, that the aforementioned Bridge is located nearly ½ mile upstream of the LCP site. Surface water from the LCP site drained eastward to the Arthur Kill not toward

the upstream Bridge. The existence of the Bridge is only mentioned because, for all other years of LCP operation, there was a confirmed dam, berm and/or topographical barrier located upstream of the LCP Site. However, even without upgradient topographical obstructions, the surface water, shallow groundwater and deep groundwater beneath LCP all flowed directly to the Arthur Kill. LCP is located on the shoreline of the Arthur Kill and the Arthur Kill is the dominant region groundwater and surface water discharge point. Given that the groundwater and surface water flow from LCP was to the Arthur Kill, water would not migrate upgradient through the drainage system nearly ½ mile to Piles Creek, even in the absence of a physical upgradient barrier.

Industrial activities at the LCP site began in 1955, at which point water flowed to South Branch Creek and onward to the Arthur Kill. The ISP-ESI drainage system connected to South Branch Creek upstream of the LCP site, as described above. Later, the orientation of South Branch Creek on the LCP site was significantly modified where it was relocated by 1966 into a covered channel (or "flume"). At the same time, the discharge of South Branch Creek to the Arthur Kill was relocated 950 feet to a point on the LCP site. Water collection on the LCP site was apparently modified at this time; the portion of South Branch Creek that previously looped around the southern side of the process area was replaced by a continuous concrete drainage trench. This trench directed stormwater to a treatment area prior to discharge to South Branch Creek. Around the same time, process water handling was also modified in which this water was collected and pumped to the ISP-ESI treatment plant. This wastewater treatment arrangement was used by LCP until the plant ceased operation in 1982.

Figures

BROWN AND CALDWELL

ISP-ESI SITE

LCP CHEMICALS INC. SITE

GAF-15D
GAF-15S (5.81)
RP-7 (3.63)
RP-8 (4.53)
RP-10 (4.43)
WP-27 (4.72)
GAF-10D
GAF-10S (4.54)
MW-17 (4.56)
MW-18 (4.72)
MW-16 (5.01)
MW-19 (5.19)
RP-1 (2.57)
MW-20 (3.68)
MW-15* (1.97)
MW-11 (5.40)
MW-14 (3.64)
MW-12 (6.59)
MW-13 (6.85)
MW-9 (3.16)
MW-10 (2.97)
MW-8 (2.30)
MW-7 (2.22)
MW-6 (2.29)
RP-2 (DRY @ 2.61)
SG-1** (7.22)
RP-3 (2.72)
RP-5 (3.27)
RP-4 (6.36)
RP-11 (-0.88)

Note:

* - Anomalous water level measurement not included in contouring

** - Mean tidal measurement at SG-1 was used for mapping rather than instantaneous measurement shown on map

Monitoring Well
Piezometer
Surface Water Refrence Point
Potentiometric Contour (Feet)
Property Line

N

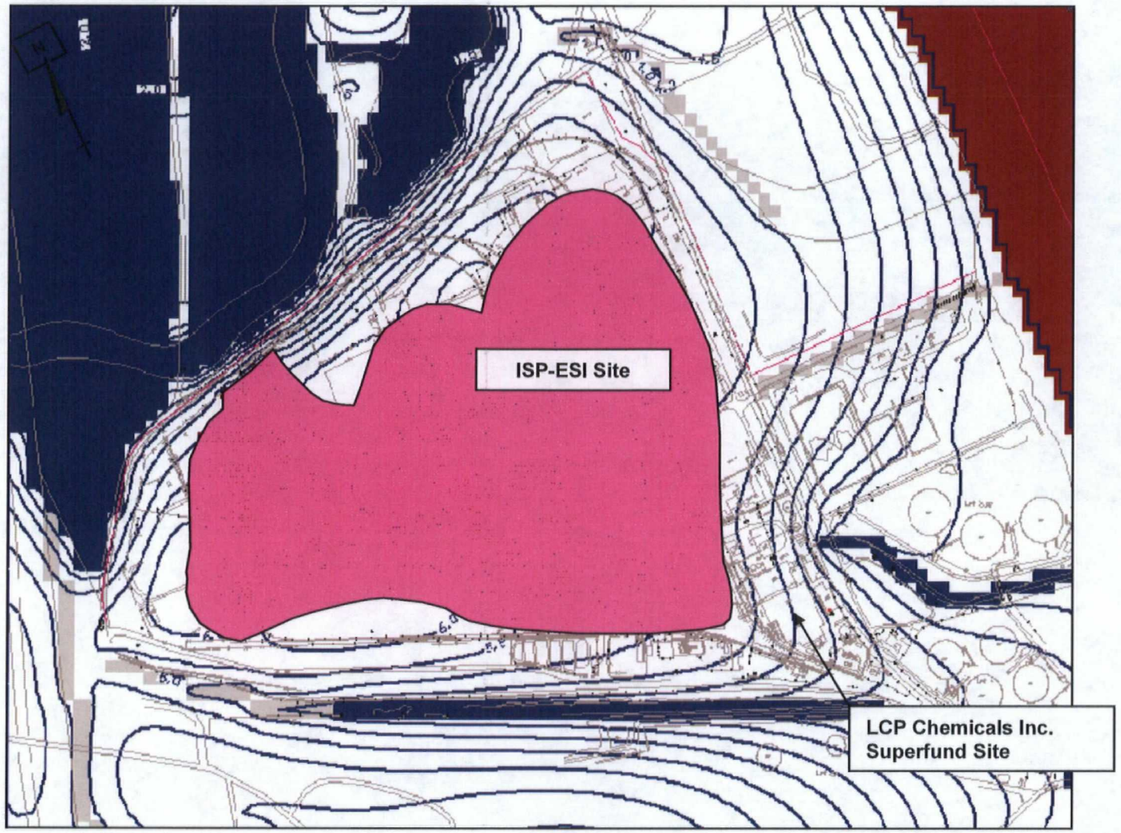
0 100 200 400 Feet

FIGURE 1-1
POTENTIOMETRIC SURFACE MAP - JANUARY 22, 2002

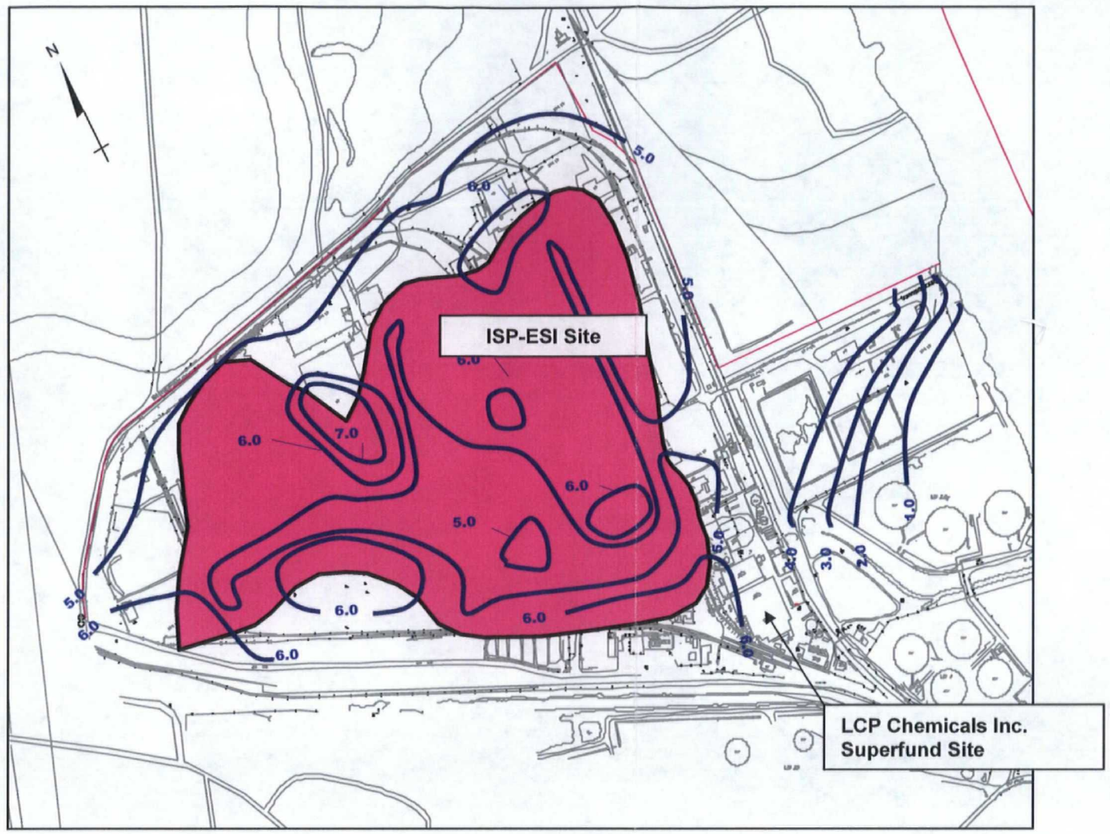
LCP Chemicals, Inc. Superfund Site
Linden, New Jersey

BROWN AND CALDWELL

22241.150



Computer-Predicted Conditions



Observed Conditions

LEGEND

- River Cells
- Constant Head Cells
- Drain Cells
- Ditch System Capture Zone
- Computed Groundwater Contours in Feet

Map Source:

"Groundwater Flow Model Report for the ISP Linden Site", (Brown and Caldwell, 2002)

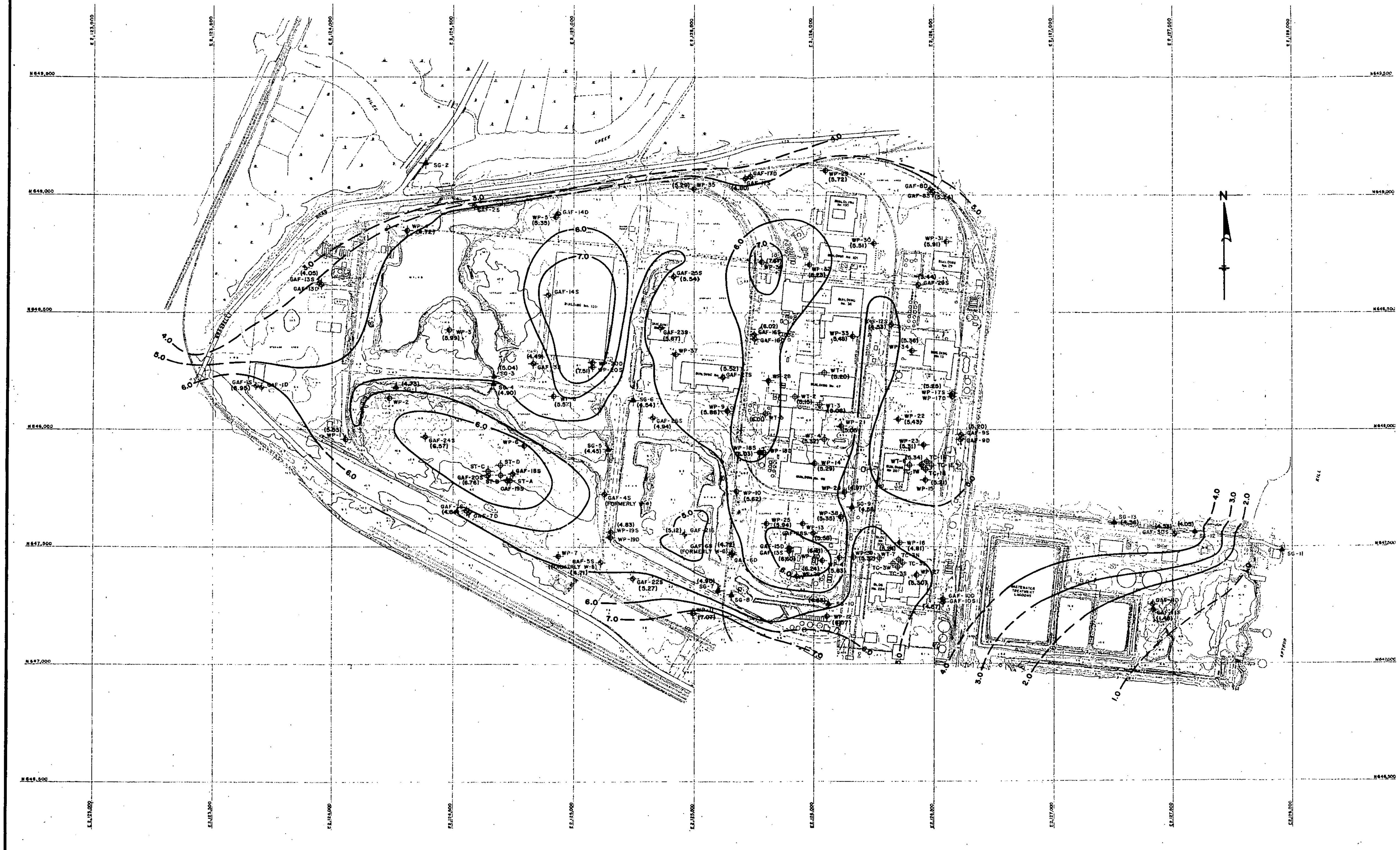
LEGEND

- Ditch System Capture Zone
- Measured Groundwater Contours (11-19-90) in Feet

FIGURE 1-2
Comparison of Observed and Computer-Predicted Ditch System Capture Zones
ISP Linden
Linden, NJ

BROWN AND CALDWELL

\\bcmah01\projects\^Clients\LCP\21405(Ph_I_RI)\PhaseII_RI_WP\Historic_Drainage\Figures\Fig1-2(Model_Map).ppt



LEGEND

- GAF-7S — LOCATION OF MONITORING WELL
- WP-8 — LOCATION OF WELLPOINT OR STANDPIPE
- TC-IN — LOCATION OF WELLS INSTALLED BY OTHERS
- LOCATION OF STAFF GAUGE
- EDGE OF SURFACE WATER BODIES
- —3.5— WATER TABLE CONTOUR LINE (DASHED WHERE INFERRED)
- (4.05) WATER TABLE ELEVATION (FEET ABOVE/BELOW MEAN SEA LEVEL)

NOTE:

STAFF GAUGE MEASUREMENTS COLLECTED FROM TIDAL SURFACE WATER BODIES DO NOT CORRELATE WITH GROUNDWATER ELEVATIONS WHICH ARE NOT EFFECTED BY THE TIDE.

200 0 200 400
scale feet

NO.	REVISIONS	REV'D BY	DATE	APPRO'D BY
2	MONITORING WELL AND WELL POINT UPDATE	J.H.S.	11/2/90	S.D.M.
1	MONITORING WELL AND WELLPOINT UPDATE	J.H.S.	6/5 /89	S.D.M.

ECKENFELDER INC.
Nashville, Tennessee
Mahwah, New Jersey

GAF CHEMICALS CORPORATION
LINDEN UNION COUNTY, NEW JERSEY

WATER TABLE CONTOUR MAP
UPPER WATER BEARING ZONE
(12-17-90)

SCALE: AS SHOWN

DRAWN BY	DATE	CHECKED BY	APPROVED BY	
J.H.S.	5/89	S.D.M.	R.D.M.	5/91

FIGURE 1-3

DRAWING NUMBER 6070-021

LEGEND

- GAF-7S — LOCATION OF MONITORING WELL
- WP-8 — LOCATION OF WELLPOINT OR STANDPIPE
- TC-1N — LOCATION OF WELLS INSTALLED BY OTHERS
- LOCATION OF STAFF GAUGE
- EDGE OF SURFACE WATER BODIES
- —5.0— PIEZOMETRIC SURFACE CONTOUR LINE (DASHED WHERE INFERRED)
- (3.56) WATER TABLE ELEVATION (FEET ABOVE / BELOW MEAN SEA LEVEL)

NOTE:

PIEZOMETRIC MEASUREMENTS IN BEDROCK WELLS HAVE BEEN CONVERTED TO EQUIVALENT FRESH WATER HEAD THROUGH A CORRECTION FOR WATER DENSITY. REFER TO TEXT SECTION 4.2.4.

200 0 200 400
scale feet

NO.	REVISIONS	REV'D BY	DATE	APPR'D BY
2	MONITORING WELL AND WELL POINT UPDATE	J.H.S.	11/2/90	S.D.M.
1	MONITORING WELL AND WELLPOINT UPDATE	J.H.S.	6/5/89	S.D.M.

ECKENFELDER INC.
Nashville, Tennessee
Mahwah, New Jersey

SCALE: AS SHOWN

DRAWN BY	DATE	CHECKED BY	APPROVED BY
J.H.M.	3/90	S.D.M.	R.D.M. 5/91

GAF CHEMICALS CORPORATION
LINDEN UNION COUNTY, NEW JERSEY

CORRECTED PIEZOMETRIC CONTOUR MAP
BEDROCK AQUIFER
(11-19-90)

FIGURE 1-4

DRAWING NUMBER
6070-023

PILES CREEK

ISP-ESI SITE

LCP CHEMICALS
INC. SITE

SOUTH BRANCH CREEK

ARTHUR KILL

LEGEND

- Current LCP Property Line
- Current ISP Property Line
- Location of Former Tidal Creeks

NOTES:
1. SITE MAP AND EXISTING SITE FEATURES AS OF 4/05/02 OBTAINED FROM DRAWING TITLED "ALTA/ACSM LAND TITLE SURVEY, ISP ENVIRONMENTAL SERVICES INC., BLOCK 587, LOTS 1 & 2. 10", PREPARED BY KELLER & KIRKPATRICK, (PROJ NO. 2020408. 10, 8/26/03).

2. LOCATIONS OF FORMER TIDAL CREEKS FROM RIPARIAN CLAIMS MAPS OBTAINED FROM NJDEP, LAND USE MANAGEMENT COMPLIANCE, AND BUREAU OF TIDELANDS MANAGEMENT AS SHOWN ON KELLER & KIRKPATRICK DRAWING LISTED IN NO. 1, ABOVE.

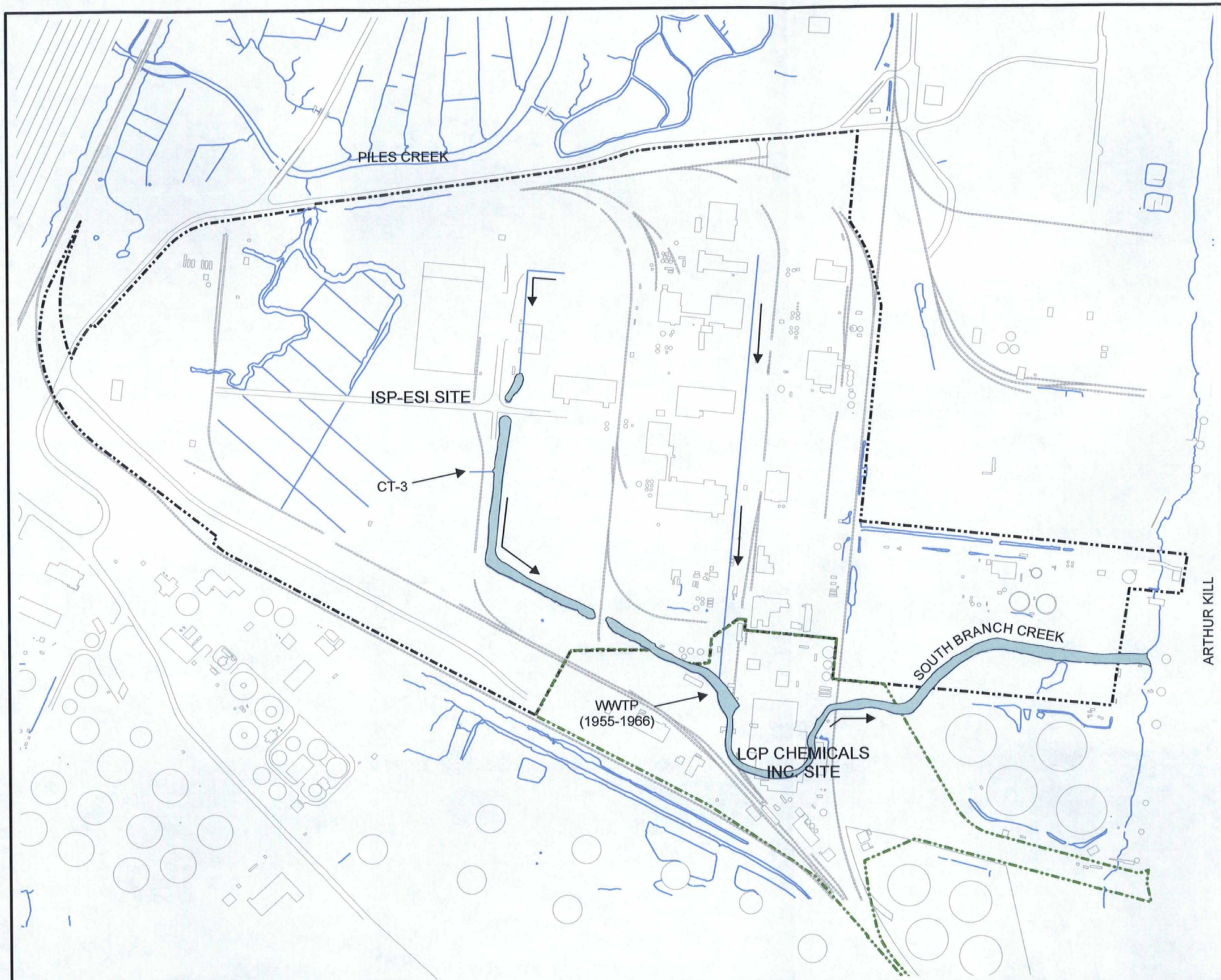
N

400 200 0 400
Feet

FIGURE 1-5
LOCATION OF HISTORIC
TIDAL CREEKS

LCP Chemicals, Inc. Superfund Site
Linden, New Jersey

BROWN AND CALDWELL



LEGEND

- Current LCP Property Line
- Current ISP Property Line
- Site Drainage Channels
- Surface Water Flow Direction

NOTES:
1. SITE MAP AND EXISTING SITE FEATURES AS OF 4/05/02 ARE SHOWN IN GRAY. INFORMATION OBTAINED FROM DRAWING TITLED "ALTA/ACSM LAND TITLE SURVEY, ISP ENVIRONMENTAL SERVICES INC., BLOCK 587, LOTS 1 & 2. 10", PREPARED BY KELLER & KIRKPATRICK, (PROJ NO. 2020408. 10, 8/26/03).

2. LOCATIONS OF RECENT DRAINAGE CHANNELS FROM KELLER & KIRKPATRICK DRAWING NO.1, ABOVE, AND ECKENFE;DER INC. DRAWING LISTED IN NO. 3, ABOVE.

3. LOCATIONS OF HISTORIC DRAINAGE CHANNELS FROM ECKENFELDER INC. DRAWING LISTED IN NO. 3 ABOVE.

4. LOCATION OF FORMER SOUTH BRANCH CREEK CHANNEL SOUTH OF THE LCP SITE OBTAINED BY BROWN & CALDWELL FROM AERIAL PHOTOGRAPHY DATED 5/16/54.

N

400 200 0 400

Feet

FIGURE 1-6
HISTORIC DRAINAGE PATTERN MAP
(1951-1966)

LCP Chemicals, Inc. Superfund Site
Linden, New Jersey

BROWN AND CALDWELL

P:/GIS/LCP/Fig_1-6(Hist_Drainage_1951-1966).mxd

PILES CREEK

DAM

ISP-ESI SITE

CT-3

WWTP
(1966-1977)

LCP CHEMICALS
INC. SITE

DRAINAGE TRENCH

SOUTH BRANCH CREEK

ARTHUR KILL

LEGEND

- Current LCP Property Line
- Current ISP Property Line
- Site Drainage Channels
- Surface Water Flow Direction

NOTES:
1. SITE MAP AND EXISTING SITE FEATURES AS OF 4/05/02 ARE SHOWN IN GRAY. INFORMATION OBTAINED FROM DRAWING TITLED "ALTA/ACSM LAND TITLE SURVEY, ISP ENVIRONMENTAL SERVICES INC., BLOCK 587, LOTS 1 & 2. 10", PREPARED BY KELLER & KIRKPATRICK, (PROJ NO. 2020408. 10, 8/26/03).

2. LOCATIONS OF RECENT DRAINAGE CHANNELS FROM KELLER & KIRKPATRICK DRAWING NO.1, ABOVE, AND ECKENFE;DER INC. DRAWING NO. 6070-003 , ABOVE.

3. LOCATIONS OF HISTORIC DRAINAGE CHANNELS FROM ECKENFELDER INC. DRAWING LISTED IN NO. 3 ABOVE.

4. LOCATION OF FORMER SOUTH BRANCH CREEK CHANNEL SOUTH OF THE LCP SITE OBTAINED BY BROWN & CALDWELL FROM AERIAL PHOTOGRAPHY DATED 5/16/54.

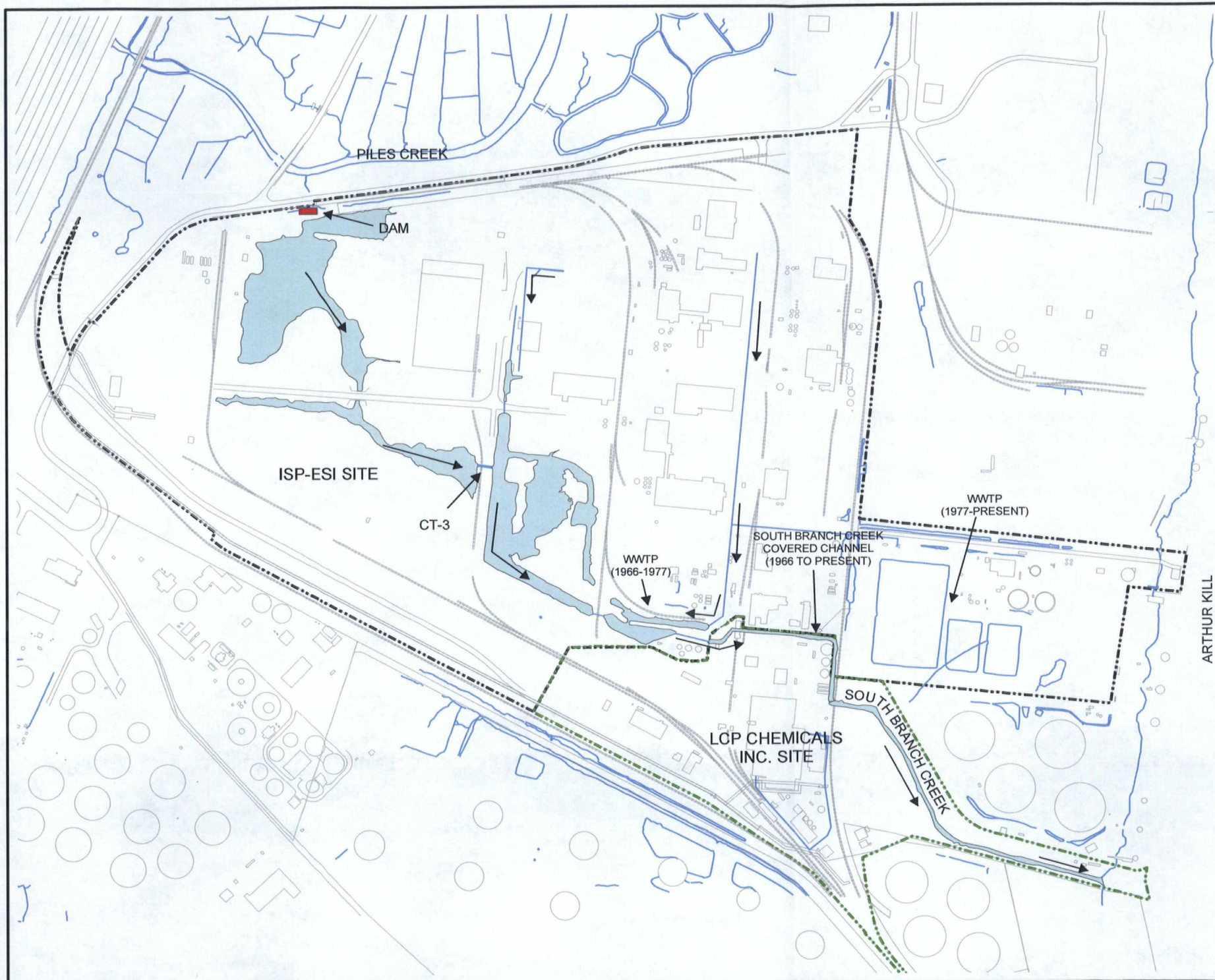
N

400 200 0 400
Feet

FIGURE 1-7
HISTORIC DRAINAGE
PATTERN MAP
(1966-1971)
LCP Chemicals, Inc. Superfund Site
Linden, New Jersey

BROWN AND CALDWELL

P:/GIS/LCP/Fig_1-7(Hist_Drainage_1966-1971).mxd



LEGEND

- Current LCP Property Line
- Current ISP Property Line
- Site Drainage Channels
- Surface Water Flow Direction

NOTES:

1. SITE MAP AND EXISTING SITE FEATURES AS OF 4/05/02 ARE SHOWN IN GRAY. INFORMATION OBTAINED FROM DRAWING TITLED "ALTA/ACSM LAND TITLE SURVEY, ISP ENVIRONMENTAL SERVICES INC., BLOCK 587, LOTS 1 & 2. 10", PREPARED BY KELLER & KIRKPATRICK, (PROJ NO. 2020408. 10, 8/26/03).

2. LOCATIONS OF RECENT DRAINAGE CHANNELS FROM KELLER & KIRKPATRICK DRAWING NO.1, ABOVE, AND ECKENFE;DER INC. DRAWING NO. 6070-003 , ABOVE.

3. LOCATIONS OF HISTORIC DRAINAGE CHANNELS FROM ECKENFELDER INC. DRAWING LISTED IN NO. 3 ABOVE.

4. LOCATION OF FORMER SOUTH BRANCH CREEK CHANNEL SOUTH OF THE LCP SITE OBTAINED BY BROWN & CALDWELL FROM AERIAL PHOTOGRAPHY DATED 5/16/54.

N

400 200 0 400

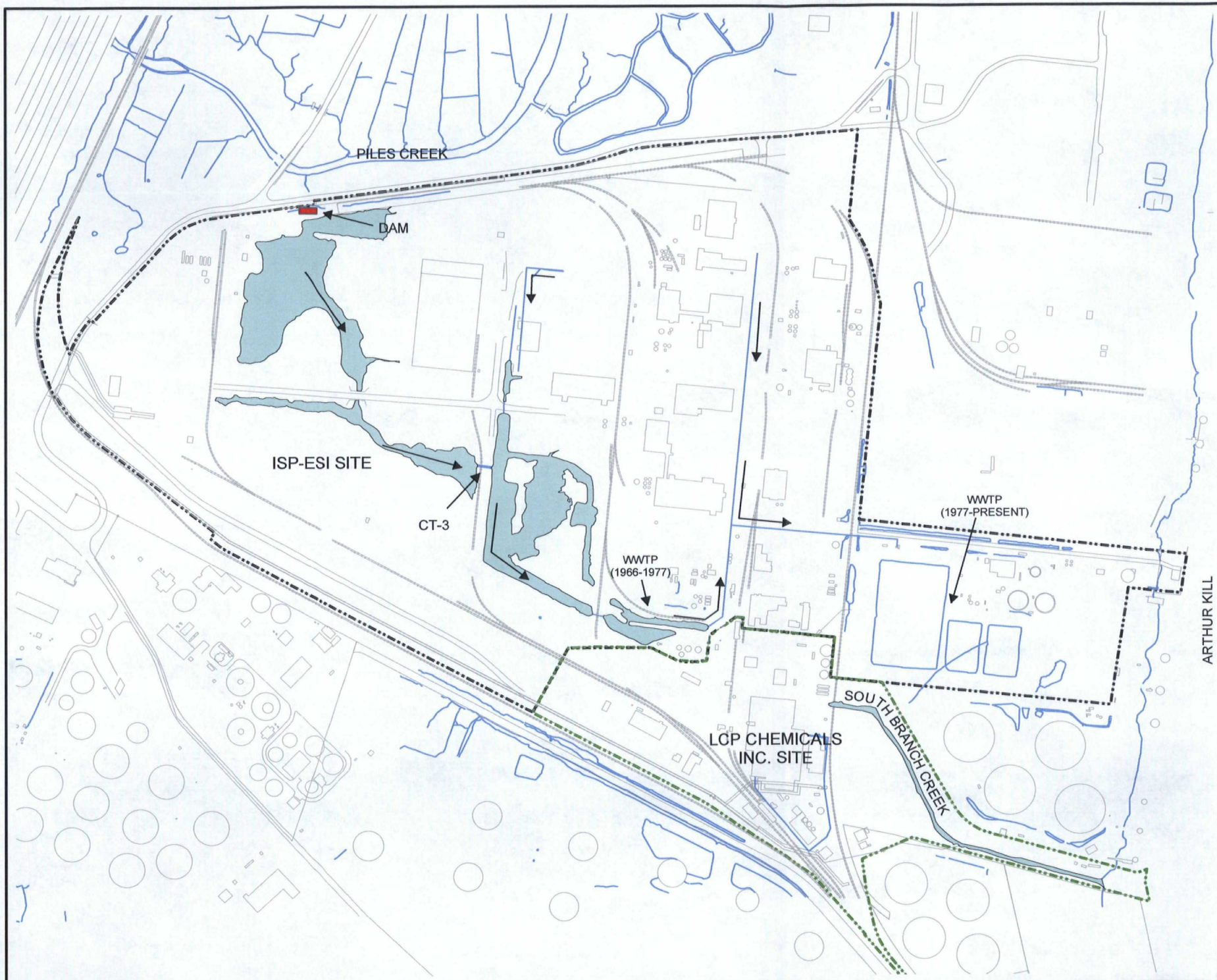
Feet

FIGURE 1-8
HISTORIC DRAINAGE
PATTERN MAP
(1971-1977)

LCP Chemicals, Inc. Superfund Site
Linden, New Jersey

BROWN AND CALDWELL

P:/GIS/LCP/Fig_1-8(Hist_Drainage_1971-1977).mxd



LEGEND

- Current LCP Property Line
- Current ISP Property Line
- Site Drainage Channels
- Surface Water Flow Direction

NOTES:

1. SITE MAP AND EXISTING SITE FEATURES AS OF 4/05/02 ARE SHOWN IN GRAY. INFORMATION OBTAINED FROM DRAWING TITLED "ALTA/ACSM LAND TITLE SURVEY, ISP ENVIRONMENTAL SERVICES INC., BLOCK 587, LOTS 1 & 2. 10", PREPARED BY KELLER & KIRKPATRICK, (PROJ NO. 2020408. 10, 8/26/03).

2. LOCATIONS OF RECENT DRAINAGE CHANNELS FROM KELLER & KIRKPATRICK DRAWING NO.1, ABOVE, AND ECKENFE;DER INC. DRAWING NO. 6070-003 , ABOVE.

3. LOCATIONS OF HISTORIC DRAINAGE CHANNELS FROM ECKENFELDER INC. DRAWING LISTED IN NO. 3 ABOVE.

4. LOCATION OF FORMER SOUTH BRANCH CREEK CHANNEL SOUTH OF THE LCP SITE OBTAINED BY BROWN & CALDWELL FROM AERIAL PHOTOGRAPHY DATED 5/16/54.

N

400 200 0 400

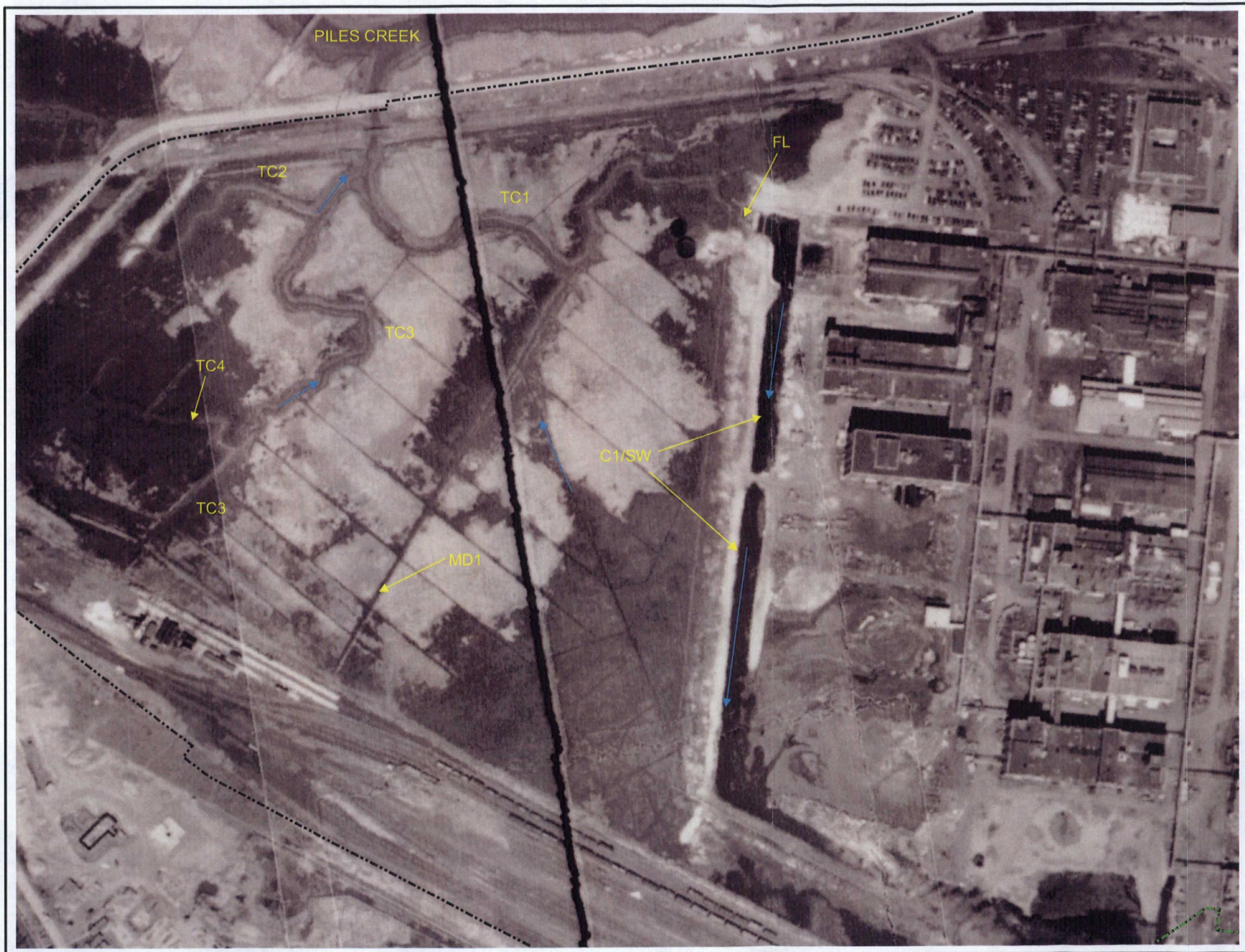
Feet

FIGURE 1-9
HISTORIC DRAINAGE
PATTERN MAP
(1977-2003)

LCP Chemicals, Inc. Superfund Site
Linden, New Jersey

BROWN AND CALDWELL

P:/GIS/LCP/Fig_1-9(Hist_Drainage_1977-2003).mxd



LEGEND

SW	Standing Water
FL	Fill
C	Channel
TC	Tidal Creek Channel
MD	Mosquito Ditch
EOP	Ethylene Oxide Plant
B120	Building 120
R	Road
CT	Culvert
BR	Bridge
SBC	South Branch Creek
OPL	Overhead Power Lines

Approximate Surface Flow Direction

Current LCP Property Line

Current ISP Property Line

N

200 100 0 200

Feet

FIGURE 2-1
ISP LINDEN SITE
APRIL 20, 1951

LCP Chemicals, Inc. Superfund Site
Linden, New Jersey

BROWN AND CALDWELL

LEGEND

SW	Standing Water
FL	Fill
C	Channel
TC	Tidal Creek Channel
MD	Mosquito Ditch
EOP	Ethylene Oxide Plant
B120	Building 120
R	Road
CT	Culvert
BR	Bridge
SBC	South Branch Creek
OPL	Overhead Power Lines

Apparent Surface Flow Direction

Current LCP Property Line

Current ISP Property Line

N

400 200 0 400

Feet

FIGURE 2-2
ISP LINDEN SITE
AND LCP SITE
APRIL 20, 1951

LCP Chemicals, Inc. Superfund Site
Linden, New Jersey

BROWN AND CALDWELL

LEGEND

SW	Standing Water
FL	Fill
C	Channel
TC	Tidal Creek Channel
MD	Mosquito Ditch
EOP	Ethylene Oxide Plant
B120	Building 120
R	Road
CT	Culvert
BR	Bridge
SBC	South Branch Creek
OPL	Overhead Power Lines

Approximate Surface Flow Direction

Current LCP Property Line

Current ISP Property Line

N

200 100 0 200

Feet

FIGURE 2-3
ISP LINDEN SITE
APRIL 20, 1954

LCP Chemicals, Inc. Superfund Site
Linden, New Jersey

BROWN AND CALDWELL

LEGEND

SW	Standing Water
FL	Fill
C	Channel
TC	Tidal Creek Channel
MD	Mosquito Ditch
EOP	Ethylene Oxide Plant
B120	Building 120
R	Road
CT	Culvert
BR	Bridge
SBC	South Branch Creek
OPL	Overhead Power Lines

Apparent Surface Flow Direction

Current LCP Property Line

Current ISP Property Line

N

400 200 0 400

Feet

FIGURE 2-4
ISP LINDEN SITE
AND LCP SITE
APRIL 20, 1954

LCP Chemicals, Inc. Superfund Site
Linden, New Jersey

BROWN AND CALDWELL

LEGEND

SW	Standing Water
FL	Fill
C	Channel
TC	Tidal Creek Channel
MD	Mosquito Ditch
EOP	Ethylene Oxide Plant
B120	Building 120
R	Road
CT	Culvert
BR	Bridge
SBC	South Branch Creek
OPL	Overhead Power Lines

Apparent Surface Flow Direction

Current LCP Property Line

Current ISP Property Line

N

200 100 0 200

Feet

FIGURE 2-5
ISP LINDEN SITE
MAY 16, 1954

LCP Chemicals, Inc. Superfund Site
Linden, New Jersey

BROWN AND CALDWELL

LEGEND

SW	Standing Water
FL	Fill
C	Channel
TC	Tidal Creek Channel
MD	Mosquito Ditch
EOP	Ethylene Oxide Plant
B120	Building 120
R	Road
CT	Culvert
BR	Bridge
SBC	South Branch Creek
OPL	Overhead Power Lines

Apparent Surface Flow Direction

Current LCP Property Line

Current ISP Property Line

N

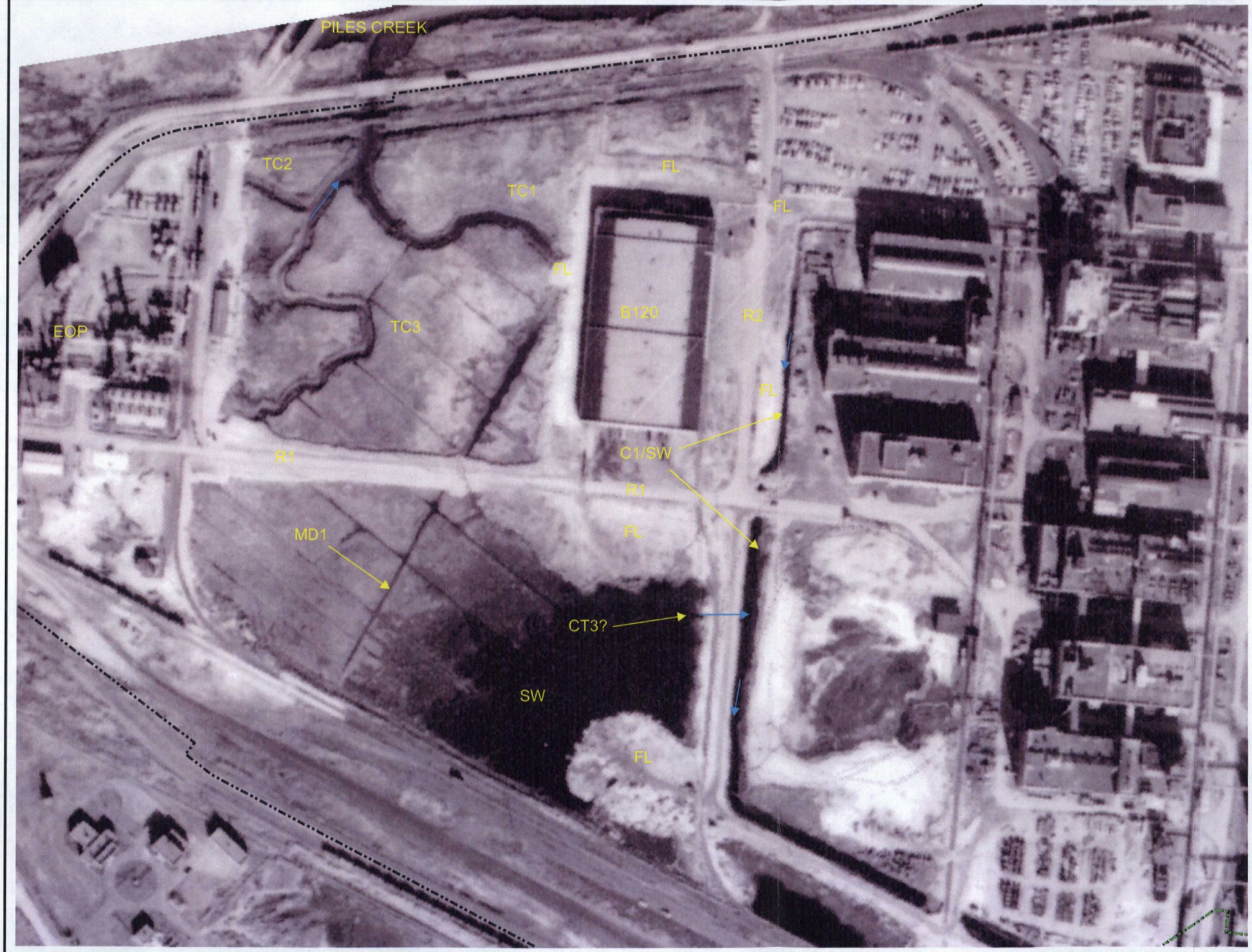
400 200 0 400

Feet

FIGURE 2-6
ISP LINDEN SITE
AND LCP SITE
MAY 16, 1954

LCP Chemicals, Inc. Superfund Site
Linden, New Jersey

BROWN AND CALDWELL



LEGEND

SW	Standing Water
FL	Fill
C	Channel
TC	Tidal Creek Channel
MD	Mosquito Ditch
EOP	Ethylene Oxide Plant
B120	Building 120
R	Road
CT	Culvert
BR	Bridge
SBC	South Branch Creek
OPL	Overhead Power Lines

Apparent Surface Flow Direction

Current LCP Property Line

Current ISP Property Line

N

200 100 0 200
Feet

FIGURE 2-7
ISP LINDEN SITE
NOVEMBER 20, 1958

LCP Chemicals, Inc. Superfund Site
Linden, New Jersey

BROWN AND CALDWELL

LEGEND

SW	Standing Water
FL	Fill
C	Channel
TC	Tidal Creek Channel
MD	Mosquito Ditch
EOP	Ethylene Oxide Plant
B120	Building 120
R	Road
CT	Culvert
BR	Bridge
SBC	South Branch Creek
OPL	Overhead Power Lines

Apparent Surface Flow Direction

Current LCP Property Line

Current ISP Property Line

N

400 200 0 400

Feet

FIGURE 2-8
ISP LINDEN SITE
AND LCP SITE
NOVEMBER 20, 1958

LCP Chemicals, Inc. Superfund Site
Linden, New Jersey

BROWN AND CALDWELL

LEGEND

SW	Standing Water
FL	Fill
C	Channel
TC	Tidal Creek Channel
MD	Mosquito Ditch
EOP	Ethylene Oxide Plant
B120	Building 120
R	Road
CT	Culvert
BR	Bridge
SBC	South Branch Creek
OPL	Overhead Power Lines

Apparent Surface Flow Direction

Current LCP Property Line

Current ISP Property Line

N

200 100 0 200 Feet

FIGURE 2-9
ISP LINDEN SITE
APRIL 3, 1959

LCP Chemicals, Inc. Superfund Site
Linden, New Jersey

BROWN AND CALDWELL

LEGEND

SW	Standing Water
FL	Fill
C	Channel
TC	Tidal Creek Channel
MD	Mosquito Ditch
EOP	Ethylene Oxide Plant
B120	Building 120
R	Road
CT	Culvert
BR	Bridge
SBC	South Branch Creek
OPL	Overhead Power Lines

Apparent Surface Flow Direction

Current LCP Property Line

Current ISP Property Line

N

400 200 0 400 Feet

FIGURE 2-10
ISP LINDEN SITE
AND LCP SITE
APRIL 3, 1959

LCP Chemicals, Inc. Superfund Site
Linden, New Jersey

BROWN AND CALDWELL

LEGEND

SW	Standing Water
FL	Fill
C	Channel
TC	Tidal Creek Channel
MD	Mosquito Ditch
EOP	Ethylene Oxide Plant
B120	Building 120
R	Road
CT	Culvert
BR	Bridge
SBC	South Branch Creek
OPL	Overhead Power Lines

Apparent Surface Flow Direction

Current LCP Property Line

Current ISP Property Line

N

200 100 0 200

Feet

FIGURE 2-11
ISP LINDEN SITE
APRIL 23, 1961

LCP Chemicals, Inc. Superfund Site
Linden, New Jersey

BROWN AND CALDWELL

LEGEND

SW	Standing Water
FL	Fill
C	Channel
TC	Tidal Creek Channel
MD	Mosquito Ditch
EOP	Ethylene Oxide Plant
B120	Building 120
R	Road
CT	Culvert
BR	Bridge
SBC	South Branch Creek
OPL	Overhead Power Lines

Apparent Surface Flow Direction

Current LCP Property Line

Current ISP Property Line

N

400 200 0 400

Feet

FIGURE 2-12
ISP LINDEN SITE
AND LCP SITE
APRIL 23, 1961

LCP Chemicals, Inc. Superfund Site
Linden, New Jersey

BROWN AND CALDWELL

LEGEND

SW	Standing Water
FL	Fill
C	Channel
TC	Tidal Creek Channel
MD	Mosquito Ditch
EOP	Ethylene Oxide Plant
B120	Building 120
R	Road
CT	Culvert
BR	Bridge
SBC	South Branch Creek
OPL	Overhead Power Lines

Apparent Surface Flow Direction

Current LCP Property Line

Current ISP Property Line

N

200 100 0 200 Feet

FIGURE 2-13
ISP LINDEN SITE
DECEMBER 4, 1966

LCP Chemicals, Inc. Superfund Site
Linden, New Jersey

BROWN AND CALDWELL

LEGEND

SW	Standing Water
FL	Fill
C	Channel
TC	Tidal Creek Channel
MD	Mosquito Ditch
EOP	Ethylene Oxide Plant
B120	Building 120
R	Road
CT	Culvert
BR	Bridge
SBC	South Branch Creek
OPL	Overhead Power Lines

Apparent Surface Flow Direction

Current LCP Property Line

Current ISP Property Line

N

400 200 0 400 Feet

FIGURE 2-14
ISP LINDEN SITE
AND LCP SITE
DECEMBER 4, 1966

LCP Chemicals, Inc. Superfund Site
Linden, New Jersey

BROWN AND CALDWELL

LEGEND

SW	Standing Water
FL	Fill
C	Channel
TC	Tidal Creek Channel
MD	Mosquito Ditch
EOP	Ethylene Oxide Plant
B120	Building 120
R	Road
CT	Culvert
BR	Bridge
SBC	South Branch Creek
OPL	Overhead Power Lines

Apparent Surface Flow Direction

Current LCP Property Line

Current ISP Property Line

N

200 100 0 200 Feet

FIGURE 2-15
ISP LINDEN SITE
APRIL 11, 1967

LCP Chemicals, Inc. Superfund Site
Linden, New Jersey

BROWN AND CALDWELL

LEGEND

SW	Standing Water
FL	Fill
C	Channel
TC	Tidal Creek Channel
MD	Mosquito Ditch
EOP	Ethylene Oxide Plant
B120	Building 120
R	Road
CT	Culvert
BR	Bridge
SBC	South Branch Creek
OPL	Overhead Power Lines

Apparent Surface Flow Direction

Current LCP Property Line

Current ISP Property Line

N

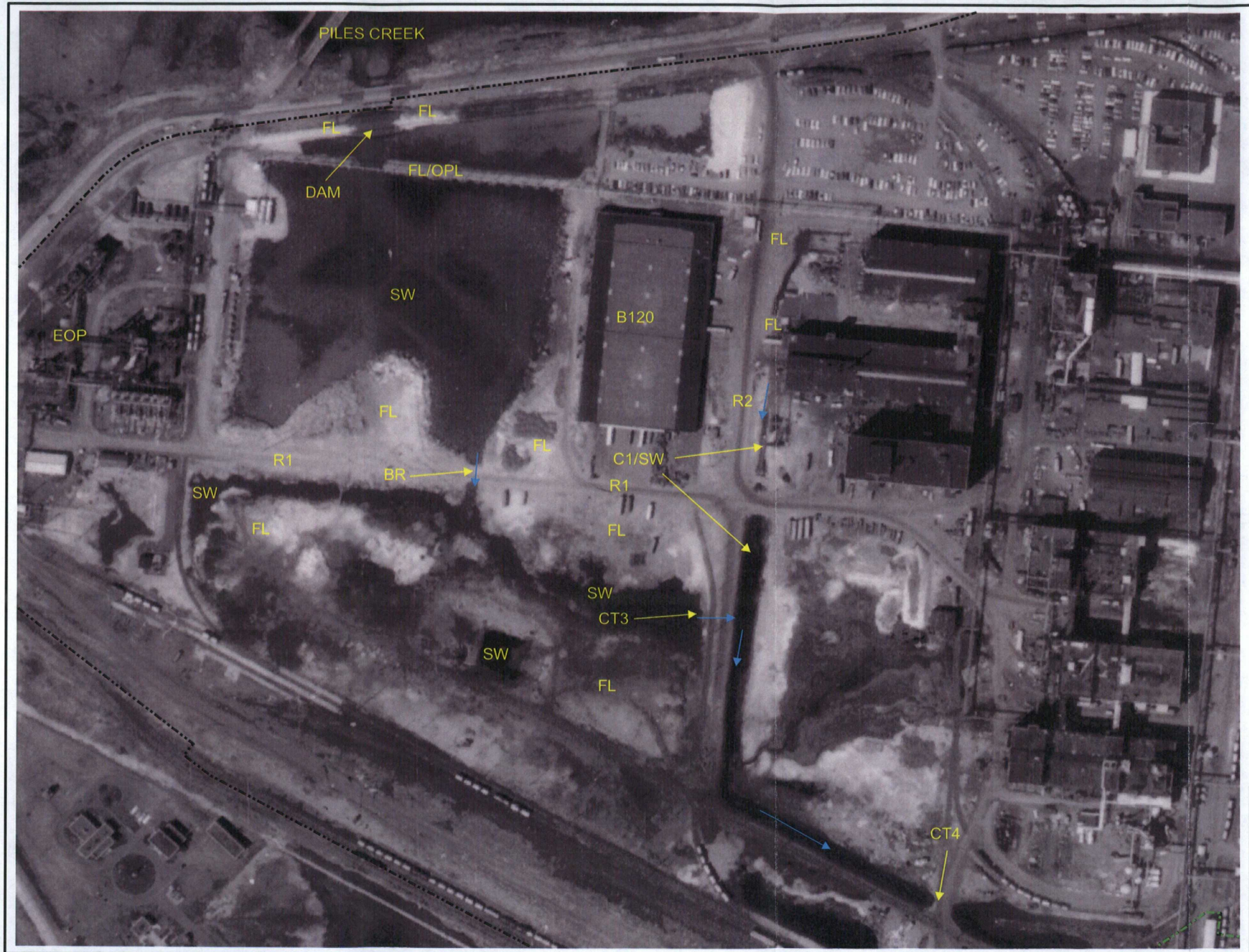
400 200 0 400

Feet

FIGURE 2-16
ISP LINDEN SITE
AND LCP SITE
APRIL 11, 1967

LCP Chemicals, Inc. Superfund Site
Linden, New Jersey

BROWN AND CALDWELL



LEGEND

SW	Standing Water
FL	Fill
C	Channel
TC	Tidal Creek Channel
MD	Mosquito Ditch
EOP	Ethylene Oxide Plant
B120	Building 120
R	Road
CT	Culvert
BR	Bridge
SBC	South Branch Creek
OPL	Overhead Power Lines

→ Apparent Surface Flow Direction

Current LCP Property Line

Current ISP Property Line

N

200 100 0 200 Feet

FIGURE 2-17
ISP LINDEN SITE
APRIL 16, 1968

LCP Chemicals, Inc. Superfund Site
Linden, New Jersey

BROWN AND CALDWELL

LEGEND

SW	Standing Water
FL	Fill
C	Channel
TC	Tidal Creek Channel
MD	Mosquito Ditch
EOP	Ethylene Oxide Plant
B120	Building 120
R	Road
CT	Culvert
BR	Bridge
SBC	South Branch Creek
OPL	Overhead Power Lines

Apparent Surface Flow Direction

Current LCP Property Line

Current ISP Property Line

N

400 200 0 400

Feet

FIGURE 2-18
ISP LINDEN SITE
AND LCP SITE
APRIL 16, 1968

LCP Chemicals, Inc. Superfund Site
Linden, New Jersey

BROWN AND CALDWELL

LEGEND

SW	Standing Water
FL	Fill
C	Channel
TC	Tidal Creek Channel
MD	Mosquito Ditch
EOP	Ethylene Oxide Plant
B120	Building 120
R	Road
CT	Culvert
BR	Bridge
SBC	South Branch Creek
OPL	Overhead Power Lines

Apparent Surface Flow Direction

Current LCP Property Line

Current ISP Property Line

N

200 100 0 200 Feet

FIGURE 2-19
ISP LINDEN SITE
APRIL 9, 1977

LCP Chemicals, Inc. Superfund Site
Linden, New Jersey

BROWN AND CALDWELL

LEGEND

SW	Standing Water
FL	Fill
C	Channel
TC	Tidal Creek Channel
MD	Mosquito Ditch
EOP	Ethylene Oxide Plant
B120	Building 120
R	Road
CT	Culvert
BR	Bridge
SBC	South Branch Creek
OPL	Overhead Power Lines

Apparent Surface Flow Direction

Current LCP Property Line

Current ISP Property Line

N

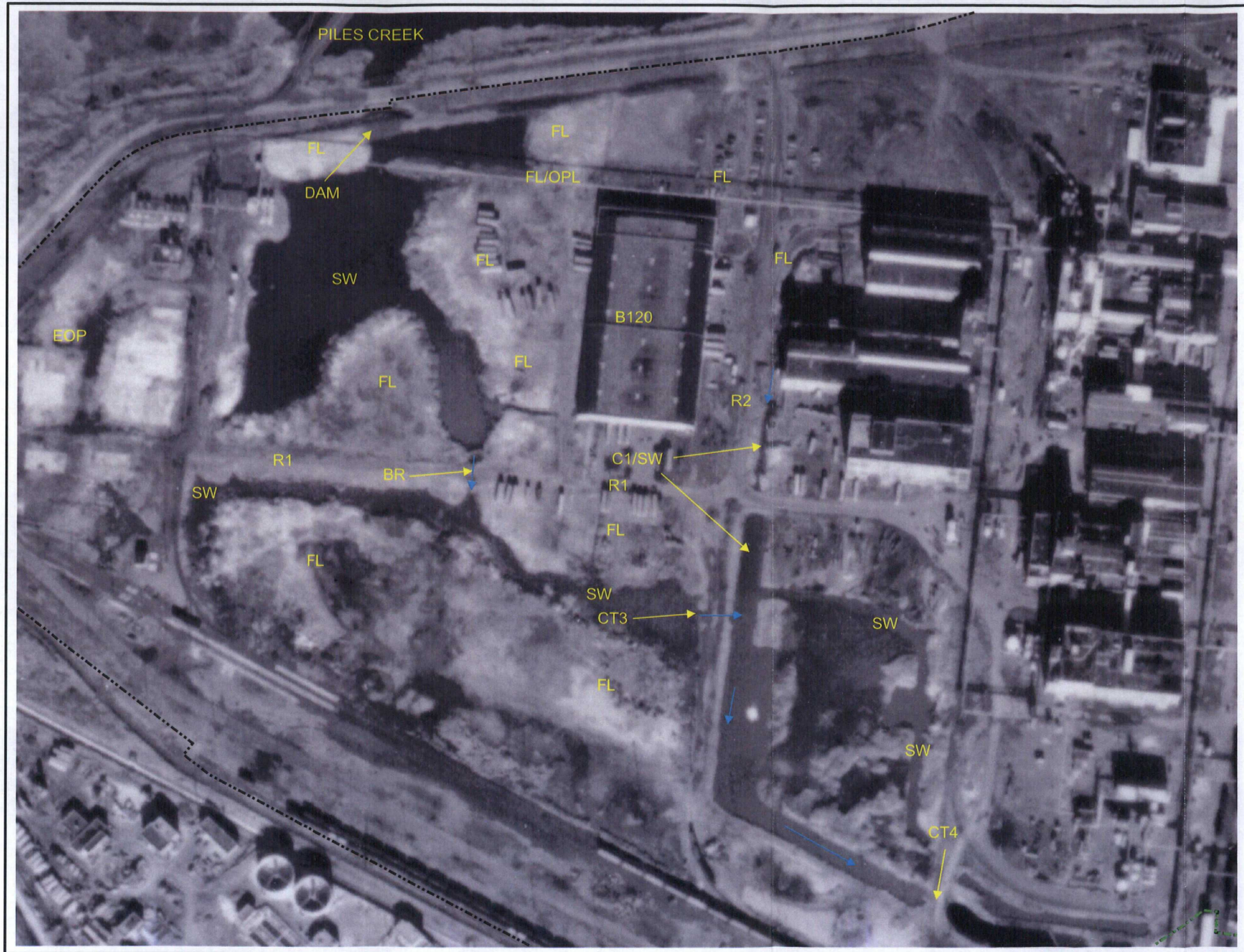
400 200 0 400

Feet

FIGURE 2-20
ISP LINDEN SITE
AND LCP SITE
APRIL 9, 1977

LCP Chemicals, Inc. Superfund Site
Linden, New Jersey

BROWN AND CALDWELL



LEGEND

SW	Standing Water
FL	Fill
C	Channel
TC	Tidal Creek Channel
MD	Mosquito Ditch
EOP	Ethylene Oxide Plant
B120	Building 120
R	Road
CT	Culvert
BR	Bridge
SBC	South Branch Creek
OPL	Overhead Power Lines

Apparent Surface Flow Direction

Current LCP Property Line

Current ISP Property Line

N

200 100 0 200 Feet

FIGURE 2-21
ISP LINDEN SITE
DECEMBER 22, 1978

LCP Chemicals, Inc. Superfund Site
Linden, New Jersey

BROWN AND CALDWELL

LEGEND

SW	Standing Water
FL	Fill
C	Channel
TC	Tidal Creek Channel
MD	Mosquito Ditch
EOP	Ethylene Oxide Plant
B120	Building 120
R	Road
CT	Culvert
BR	Bridge
SBC	South Branch Creek
OPL	Overhead Power Lines

Apparent Surface Flow Direction

Current LCP Property Line

Current ISP Property Line

N

400 200 0 400

Feet

FIGURE 2-22
ISP LINDEN SITE
AND LCP SITE
DECEMBER 22, 1978

LCP Chemicals, Inc. Superfund Site
Linden, New Jersey

BROWN AND CALDWELL

LEGEND

SW	Standing Water
FL	Fill
C	Channel
TC	Tidal Creek Channel
MD	Mosquito Ditch
EOP	Ethylene Oxide Plant
B120	Building 120
R	Road
CT	Culvert
BR	Bridge
SBC	South Branch Creek
OPL	Overhead Power Lines

→ Apparent Surface Flow Direction

Current LCP Property Line

Current ISP Property Line

N

200 100 0 200

Feet

FIGURE 2-23
ISP LINDEN SITE
NOVEMBER 15, 1988

LCP Chemicals, Inc. Superfund Site
Linden, New Jersey

BROWN AND CALDWELL

LEGEND

SW	Standing Water
FL	Fill
C	Channel
TC	Tidal Creek Channel
MD	Mosquito Ditch
EOP	Ethylene Oxide Plant
B120	Building 120
R	Road
CT	Culvert
BR	Bridge
SBC	South Branch Creek
OPL	Overhead Power Lines

Apparent Surface Flow Direction

Current LCP Property Line

Current ISP Property Line

N

400 200 0 400

Feet

FIGURE 2-24
ISP LINDEN SITE
AND LCP SITE
NOVEMBER 11, 1988

LCP Chemicals, Inc. Superfund Site
Linden, New Jersey

BROWN AND CALDWELL

LEGEND

SW	Standing Water
FL	Fill
C	Channel
TC	Tidal Creek Channel
MD	Mosquito Ditch
EOP	Ethylene Oxide Plant
B120	Building 120
R	Road
CT	Culvert
BR	Bridge
SBC	South Branch Creek
OPL	Overhead Power Lines

→ Apparent Surface Flow Direction

Current LCP Property Line

Current ISP Property Line

N

200 100 0 200

Feet

FIGURE 2-25
ISP LINDEN SITE
1995

LCP Chemicals, Inc. Superfund Site
Linden, New Jersey

BROWN AND CALDWELL

LEGEND

SW	Standing Water
FL	Fill
C	Channel
TC	Tidal Creek Channel
MD	Mosquito Ditch
EOP	Ethylene Oxide Plant
B120	Building 120
R	Road
CT	Culvert
BR	Bridge
SBC	South Branch Creek
OPL	Overhead Power Lines

Apparent Surface Flow Direction

Current LCP Property Line

Current ISP Property Line

N

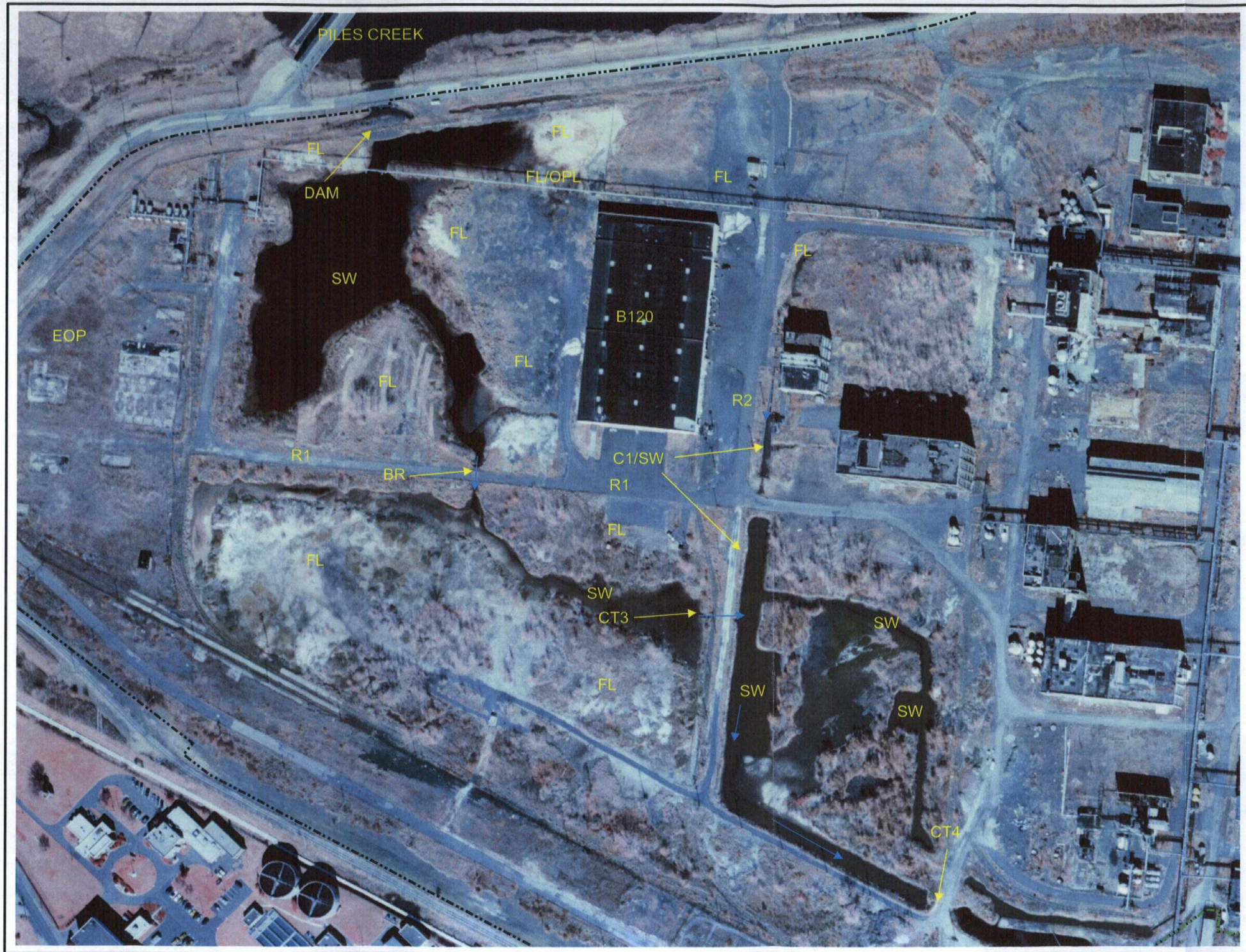
400 200 0 400

Feet

FIGURE 2-26
ISP LINDEN SITE
AND LCP SITE
1995

LCP Chemicals, Inc. Superfund Site
Linden, New Jersey

BROWN AND CALDWELL



LEGEND

SW	Standing Water
FL	Fill
C	Channel
TC	Tidal Creek Channel
MD	Mosquito Ditch
EOP	Ethylene Oxide Plant
B120	Building 120
R	Road
CT	Culvert
BR	Bridge
SBC	South Branch Creek
OPL	Overhead Power Lines

→ Apparent Surface Flow Direction

Current LCP Property Line

Current ISP Property Line

N

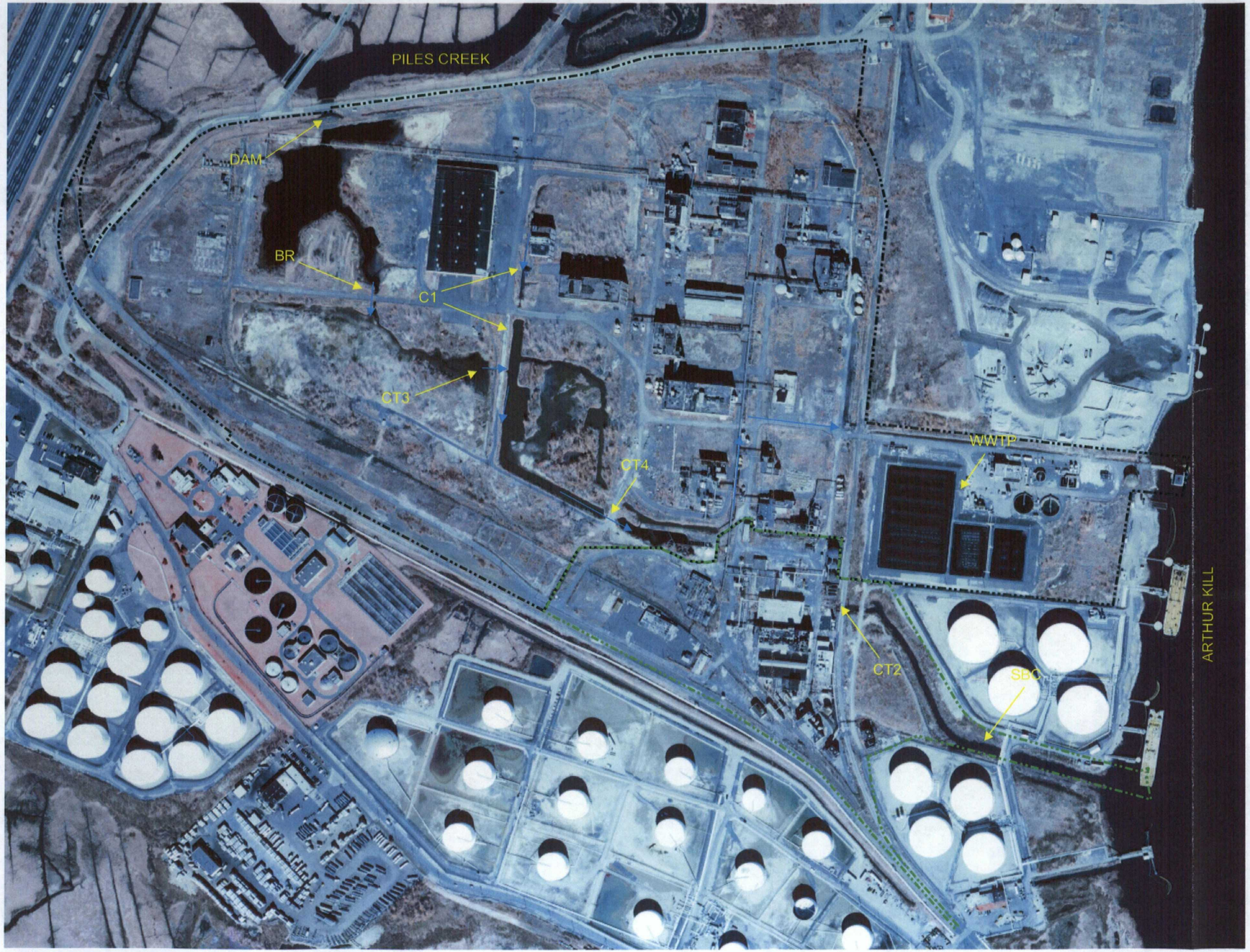
200 100 0 200

Feet

FIGURE 2-27
ISP LINDEN SITE
SPRING 2002

LCP Chemicals, Inc. Superfund Site
Linden, New Jersey

BROWN AND CALDWELL



LEGEND

SW	Standing Water
FL	Fill
C	Channel
TC	Tidal Creek Channel
MD	Mosquito Ditch
EOP	Ethylene Oxide Plant
B120	Building 120
R	Road
CT	Culvert
BR	Bridge
SBC	South Branch Creek
OPL	Overhead Power Lines

Apparent Surface Flow Direction

Current LCP Property Line

Current ISP Property Line

N

400 200 0 400

Feet

FIGURE 2-28
ISP LINDEN SITE
AND LCP SITE
SPRING 2002

LCP Chemicals, Inc. Superfund Site
Linden, New Jersey

BROWN AND CALDWELL